



**TECHNICAL SUPPORT SECTION  
DOCUMENT**

# **Sampling and Analysis Plan**

*for the . . .*

**Remedial Investigation and Feasibility Study**

*of the . . .*

**Albion-Sheridan Township Landfill**  
**Albion, Michigan**  
**May, 1992**

*prepared for . . .*

**U.S. Environmental Protection Agency**  
**Region V**  
**Chicago, Illinois**

EPA Contract No. 68-W8-0079  
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WW Engineering & Science Project No. 04011

**REMEDIAL INVESTIGATION/FEASIBILITY STUDY  
SAMPLING AND ANALYSIS PLAN  
ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN**

**Prepared for**

**U.S. ENVIRONMENTAL PROTECTION AGENCY  
REGION V  
CHICAGO, ILLINOIS**

**EPA CONTRACT NO. 68-W8-0079  
EPA WORK ASSIGNMENT NO.11-5LAN**

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**MAY 1992**

**PROJECT 04011**

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## **LIST OF ACRONYMS/ABBREVIATIONS**

ASTM	American Society for Testing and Materials
CEC	Cation Exchange Capacity
CLP	Contract Laboratory Program
DC	Direct Current
DQO	Data Quality Objective
Eh	Oxidation-Reduction Potential
EM	Electromagnetic
FID	Flame Ionization Detector
GC	Gas Chromatograph
MDNR	Michigan Department of Natural Resources
NWS	National Weather Service
ORV	Off-road Vehicle
PID	Photoionization Detector
PVC	Polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Risk Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SAS	Special Analytical Services
SOP	Standard Operating Procedures
SOW	Scope of Work
TAL	Target Analyte List
TCL	Target Compound List
U.S. EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WWES	WW Engineering & Science, Inc.

## **1.0 INTRODUCTION**

### **1.1 SCOPE AND PURPOSE**

This Sampling and Analysis Plan (SAP) for the Albion-Sheridan Township Landfill site (the "site") is considered part of the site Quality Assurance Project Plan (QAPP) and should be read in conjunction with the QAPP and the site Work Plan. This SAP defines the methods necessary to complete the Remedial Investigation (RI).

The objectives of the SAP are to present:

- The rationale and objectives used to establish sample locations and parameters; and
- Specify protocols for sampling and all other field activities.

The scope of work (SOW) described in the SAP is based on a review of existing information available for the site. The investigation has been designed to address the needs of the various uses (e.g. risk assessment and feasibility of remedial options) and data quality objectives (DQOs) identified in the QAPP and Work Plan.

DQOs are qualitative and quantitative statements specifying the required quality of the data for each specific use. There are 3 objectives in developing DQOs: 1) to obtain a well-defined SAP; 2) to identify the required quality assurance/quality control (QA/QC) procedures to ensure the quality of the data being collected; and 3) to integrate the information required by the decision makers, data used, and technical specialists associated with the RI/FS process. The ultimate DQO for each data set collected are established in the QAPP and are based on the objectives established for the RI.

The majority of the sampling protocols are detailed in WWES Standard Operating Procedures (SOPs) in Appendix A in the order in which they are referenced. Field measurements for some sample parameters will be taken in accordance with ASTM procedures. Copyright approval for the ASTM procedures referenced in this SAP is currently being sought. Upon receipt of approval, the methods will be provided in Appendix B. Sampling locations referred to in this SAP are based on preliminary field observation data. The number and location of each sampling point will be based on additional data obtained prior and subsequent to initial field activities for this RI. Ultimately, all sampling locations will be selected with the concurrence of the U.S. EPA Remedial Project Manager.

## **1.2 BACKGROUND**

The existing site conditions, background information, and conceptual model are presented in Section 1 of the Work Plan.

## **1.3 EVALUATION OF DATA NEEDS**

The data presented in Section 1 of the Work Plan have been used to design the SOW presented in this SAP. The following factors provide the basis for the scope of the investigation.

- The physiographic setting suggests ground water flows south or southwest towards the North Branch of the Kalamazoo River.
- The landfill received municipal and industrial wastes (e.g. metallic sludge).
- Both the glacial and bedrock aquifers could be impacted at the site.
- The distribution and extent of landfilling activities is not known.
- The existing data on the aquifers and soils are insufficient to characterize the hydrogeologic regime at the site.
- A liner was not constructed at the landfill.
- The landfill cover appears to be comprised of granular, permeable material.

## **2.0 PROPOSED FIELD INVESTIGATION**

### **2.1 SURVEYING OF SAMPLING LOCATIONS**

As described in the Work Plan, a site grid system will be staked prior to the commencement of field investigation activities. The grid system will provide ground control for the geophysical and soil vapor surveys (if performed) and will be used to accurately locate each collection point ultimately sampled during this RI.

Temporary and permanent benchmarks set during the installation of the grid system will be used to accurately measure all pertinent sampling point elevations in relation to a common vertical control point. During the second phase of surveying, six survey monuments will be installed on the landfill cover within the landfilled area identified during the surface geophysical investigation. The elevation of the monuments will be measured every other month throughout the RI to potentially determine if differential settling of the landfill cover is occurring. All elevations measured on-site will be measured relative to a U.S.G.S. datum.

### **2.2 SURFACE GEOPHYSICAL INVESTIGATION**

A geophysical survey utilizing several geophysical methods will be conducted at the Albion-Sheridan Township Landfill, primarily to delineate the lateral extent of the landfill and potentially contaminated soil, and to screen for the presence of a ground water plume(s). The resolution of the survey will be such that clusters of buried drums, if present, may be identified, however, such identification will be incidental. A secondary objective of the geophysical survey will be to gather information concerning the approximate depths of the landfill and possibly the depth of contaminant plumes.

The geophysical methods used will include: electromagnetic (EM) terrain conductivity profiling to laterally delineate the landfill and to screen for potential ground water contaminant plumes, and EM and/or direct current (DC) resistivity sounding to potentially determine the approximate depth of the landfill, and possibly contaminant plumes. Additional methods including magnetometry and ground penetrating radar may be used to survey suspected drum burial areas, as indicated by the EM survey. The locations of all geophysical measurements will be referenced to the site grid to be established as described in the Work Plan. The EM and resistivity data will be collected in accordance with the WWES "Electromagnetic Surveys" and "Resistivity Surveys" SOPs.

### 2.2.1 Landfill

In order to delineate the lateral boundaries of the landfill, EM measurements will be made over the site and surrounding area using a Geonics Model EM-31 Terrain Conductivity Meter. The EM-31 provides an integrated measurement of bulk terrain conductivity to a depth of up to 18 feet, depending on site conditions. In addition, the EM-31 provides a measurement of the in-phase component of the induced EM field which responds to metallic objects (both ferrous and non-ferrous). It is anticipated that the lateral boundaries of the landfill will be identifiable based on associated high terrain conductivity values or in-phase response due to the presence of buried metal debris.

The EM-31 will be operated in the vertical dipole mode to provide maximum depth penetration. Both the conductivity and in-phase response will be recorded continuously along traverse lines oriented north-south. The traverse line spacing will vary over the site, depending on the resolution desired (estimated target size). Over most of the area within the site boundaries, where targets (waste burial areas) with dimensions as small as 150 feet are of interest, traverse line spacing will be 50 feet (Figure 1). In the remainder of the site and in the area just west of the site, traverse lines will be spaced 100 feet to provide reconnaissance information. Traverse line spacing may be increased or reduced at the discretion of the on-site geophysicist.

EM-31 measurements will be recorded digitally and their locations will be referenced to the established site grid. It is estimated that EM-31 data will be collected along 42,000 lineal feet.

Anomalous areas (as indicated by the EM-31 survey results) will be investigated further with EM-34 and/or DC resistivity sounding methods to make semi-quantitative depth evaluations. If EM-31 data indicate that the disposal areas do not contain excessive metal debris, additional EM measurements will be made over the site and surrounding area using a Geonics Model EM-34 Terrain Conductivity Meter in the vertical dipole mode, with an intercoil spacing of 10 meters. In this configuration, the EM-34 provides an integrated measurement of bulk terrain conductivity to a depth of up to 50 feet, depending on site conditions. Data will be collected continuously along traverse lines oriented north-south. The length and density of traverse lines will depend on the size and number of anomalous areas indicated by the EM-31 data. It is estimated that the site and adjacent areas will be surveyed at half the density of the EM-31 survey providing for data collection along approximately 21,000 lineal feet.

DC resistivity soundings will be conducted in those areas suspected of containing relatively deep disposal trenches or pits, as indicated by the EM data. A Bison Offset Sounding System (or equivalent) will be used to measure variations of apparent resistivity with depth. These data will be interpreted using a commercial software package by Interpes Limited to produce a layered earth model in order to estimate the depth-to-bottom of selected disposal areas. The number and location of resistivity soundings will be determined by the on-site geophysicist and will depend on results of the EM surveys and general data quality.

Suspected drum disposal areas, as indicated by the EM survey, may be surveyed using a magnetometer and/or ground penetrating radar to determine the presence of steel and possibly determine the depth of burial. Two additional days of field work have been budgeted for this contingency. This work will only be performed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer. The methods employed and the extent of such surveys will be determined by the on-site geophysicist, based on EM results and site conditions.

### **2.2.2 CONTAMINANT PLUME IDENTIFICATION**

A reconnaissance geophysical survey will be run in areas south and west of the landfill site in an attempt to delineate any contaminant plume migrating off-site (Figure 1). These areas have been selected based on an expected ground water flow direction to the south or southwest at the site. It is expected that a ground water contaminant plume containing a relatively high concentration of dissolved solids will be detected using electrical methods. EM-31 (shallow) and EM-34 (deep) profiles will be run along the additional reconnaissance survey lines indicated in Figure 1. Data will be collected continuously along these profile lines (total distance of 6,300 lineal feet). Any anomalous areas will be further investigated using either EM or DC resistivity sounding techniques. The number, location and type of sounding will be determined by the on-site geophysicist and will depend upon site conditions and anomaly characteristics.

## **2.3 LANDFILL CHARACTERIZATION AND LANDFILL COVER EVALUATIONS**

### **2.3.1 LANDFILL CHARACTERIZATION**

In order to characterize the composition of the landfill, samples from within the landfill area identified during the surface geophysical survey will be evaluated. Generally, samples from the landfill refuse will be collected with a split spoon sampler by boring through the refuse with hollow stem augers in accordance with WWES' "Split Spoon Sampling" and "Soil

Boring Drilling Using Hollow-stem Augers" SOPs. Based on surface geophysical investigation results, drilling locations will be selected in areas of the landfill which have a lower probability of encountering metallic debris. Portions of some landfilled areas may be sampled by excavating test pits with a backhoe or by installing leachate monitoring wells.

All equipment used for collection of the landfill characterization samples will be decontaminated by washing or steam cleaning in accordance with WWES' "Decontamination, Downhole Sampling Equipment" SOP. Hexane, acetone, and/or methanol will only be used if visible oil or dirt cannot be removed from the sampling equipment by conventional steam cleaning or washing techniques. This will reduce the possibility of introducing volatile contaminants into a sample. The use of hexane, acetone or methanol will be documented on the boring log.

#### **2.3.1.1 Boring Samples**

Boring samples will be collected with a 2-foot long, 3-inch inside diameter split spoon sampler using methods described in WWES' "Split-Spoon Sampling" SOP. Samples of the landfill refuse will be collected continuously from ground surface to the base of the fill.

Documentation of landfill characterization sampling activities will be kept in accordance with WWES' "Field Notes/Records" and "Well Boring/Logging" SOPs. Each sample collected from within the landfill will be described, if the composition of the material allows, in accordance with WWES' "Soils Classification" SOP.

It is anticipated that no more than 3 borings will be drilled within the landfill. Data gathered during the surface geophysical investigation will be utilized to select boring locations within the landfill. The ultimate number of, and location for, landfill characterization borings will be selected based on approval from the U.S. EPA.

A headspace analysis will be performed on a portion of each sample collected above the water table with a PID or FID in accordance with WWES' "Jar Headspace Measurements in Unsaturated Soil Samples" SOP. The remaining portions of each soil/landfill refuse sample will be retained for potential submittal for chemical analyses and/or measurement of physical parameters. If the PID or FID screening registers 2 times that of the ambient air, or if the sample is stained or has unusual odors or color, the sample will be retained for possible submittal for chemical analysis. The samples for VOCs will not be composited in order to prevent the loss of volatiles. All other samples will be composited in a stainless steel bowl



using a stainless steel spatula. A summary of the number of samples and DQO for each chemical analysis is provided in Table 1.

At 5-foot intervals during sampling of materials above the water table, qualitative measurements of methane gas emanating from the augers will be taken. The measurements of methane gas will be taken with a methane-specific Draeger tube. Procedures for sampling and measuring for methane will be conducted in accordance with the manufacturers instructions.

A minimum of 1 and maximum of 2 samples from each landfill characterization borehole (maximum 6 samples total) will be submitted for chemical analyses as summarized in Table 1. Duplicate samples and trip blanks (deionized water blanks) will also be prepared and submitted for laboratory analysis in accordance with WWES' "Field QC Sample Guidelines" SOP. One duplicate sample will be submitted for every 10 investigative samples. Trip blank samples will accompany each cooler containing VOC samples. If a potential hot spot is encountered, a sample of this material may be submitted for TCLP metals analysis in order to evaluate appropriate remedial alternatives. Any boring requiring abandonment will be grouted from the bottom of the borehole to the ground surface with a cement/bentonite grout in accordance with WWES' "Soil Boring Grouting" SOP.

#### **2.3.1.2 Leachate Monitoring Wells**

While drilling the 3 landfill characterization borings, if the water table is encountered before the base of the landfill refuse, a monitoring well will be installed to collect a representative sample of the landfill leachate. The leachate monitoring wells will also provide a means of collecting water level measurements from within the landfill which will be beneficial for accurately characterizing ground water flow characteristics in the vicinity of the site and in calculating the percentage of saturated landfill refuse.

Leachate monitoring wells will be constructed of 2-inch diameter polyvinyl chloride (PVC) and the base of the well screen will be installed at the base of the landfill refuse. The screen in each leachate monitoring well will be 10-feet long and have 0.010-inch (10 slot) openings as supplied from the factory. The leachate wells will be installed through hollow stem augers in accordance with WWES' "Installation of Permanent Monitoring Wells through Hollow Stem Augers". A vented cap will be used on the top of each leachate well casing, and a locking protective steel casing will be installed over each well. The identification number of each well will be clearly marked on the well with weather-resistant materials.

Each of the leachate monitoring wells will be developed no earlier than 24 hours after installation. Well development will be done by a method which will result in surging and pumping water back and forth through the well screen in accordance with WWES' "Monitoring Well Purging With a Bladder, Keck, or Electric Submersible Pump" or "Monitoring Well Purging with a Suction Ditch Pump" SOPs. The wells will be developed until at least 3 to 5 well volumes have been evacuated and pH, temperature, and specific conductivity measurements have stabilized to within 10 percent for two successive well volumes. The pH and conductivity in each sample will be measured in accordance with WWES' "Standard Operating Procedure for Field Determination of pH" and "Standard Operating Procedure for Field Determination of Conductivity, Method 205" SOPs, respectively. Well volumes will be calculated in accordance with WWES' "Well Casing Volume Calculation" SOP.

Purged water will be containerized in 55-gallon drums for storage until the ground water analytical results can be reviewed. The drums will be labeled according to which well the water was collected and stored within a secured area until their ultimate fate can be determined. All details concerning well development including date, time, method and amount of water evacuated will be recorded by WWES personnel in a bound field logbook or on well data sheets.

Leachate samples will be collected on 2 occasions from each leachate monitoring well and submitted for chemical analyses as summarized in Table 2. Samples will be collected following WWES' "Monitoring Well Sampling with a Bailer" SOP. As the samples are collected, the pH, specific conductivity, and oxidation-reduction potential (Eh) of each sample will be measured in accordance with WWES' "Standard Operating Procedure for Field Determination of pH", "Standard Operating Procedure for Field Determination of Conductivity, Method 205", and "Field Determination of Oxidation/Reduction Potential (Eh)" SOPs, respectively. The temperature of each sample will also be measured at the time of collection. Samples collected for analysis of Target Analyte List (TAL) inorganics will be filtered at the time of collection using a 0.45-micron membrane filter. If the sample characteristics are such that the sample cannot be filtered, it will be sent as an unfiltered sample. Samples collected for analysis of TAL cyanide will not be filtered. Duplicate samples and deionized water blanks, including field blanks and trip blanks, will also be prepared and submitted for laboratory analysis in accordance with WWES' "Field QC Sample Guidelines" SOP. One field blank and 1 duplicate sample will be submitted for

every 10 investigative samples. Trip blank samples will accompany each cooler containing VOC samples.

- \* The decision to classify the leachate water as either low or medium concentration will be made in the field. If the water is either discolored, viscous, ~~or appears to be refined~~ ~~oil and water~~, then the sample will automatically be considered medium concentration. The water will be collected in containers appropriate for medium concentration, left unpreserved, and sent as medium concentration for purposes of adhering to proper appropriate shipping procedures.

If the water is clear, one to two average aliquots of preservative will be added to the sample in accordance with those specified for low concentration samples. If upon preservation, there appears to be a reaction with the preservative (the sample becomes warm or effervesces) or the pH does not change significantly, then the sample will be sent as a medium concentration sample. If no reaction occurs, the samples will be appropriately preserved and sent as low concentration samples. When scheduling these samples with Sample Management Office, they will be identified as leachate so that the lab will be notified and prepared to analyze these samples appropriately. Additionally, the lab will be requested to screen the samples prior to analysis to assess whether they are actually low or medium concentration.

All pertinent information concerning preservation of these samples will be recorded on the sample container, sample tag, and TR/COC.

- \* Note that any multi-phase sample is automatically a high concentration sample and cannot be shipped to RAS labs or the generic SAS labs.

Also, the low level generic SASs may not be effective on these leachate samples; these samples may not be able to be analyzed for the water quality parameters.

### **2.3.1.3 Test Pits (Optional)**

Test pits may be excavated in specific portions of potential hot spots identified. The decision on the necessity and objectives for test pitting will be approved by the U.S. EPA. This work will only be performed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer.

Test pits will be dug with a conventional backhoe to a maximum depth of 10 feet. All excavated materials will be piled next to the excavation and after the digging is completed, the material will be pushed back into the hole. The original landfill cover materials will be stockpiled during the excavation to be used as cover upon completion of backfilling of the test pit. Documentation of test pit excavating and sampling activities will be kept in accordance with WWES' "Field Notes/Records" SOP and, depending on the landfill refuse composition, WWES' "Soils Classification" SOP.

A description of the depth, thickness, and appearance of materials encountered will be recorded on a boring log sheet or in a bound field book dedicated to the site. Photographs will be taken of each wall and the base of each test pit. Vapors from the test pit will be periodically monitored with a PID and the level of response will be documented on the test pit log.

At 5-foot intervals during the excavating, qualitative measurements of methane gas emanating from the test pit will be taken. The measurements of methane gas will be taken with a methane-specific Draeger tube. Procedures for sampling and measuring for methane will be conducted in accordance with the manufacturer's instructions.

Grab samples of exposed materials encountered may be collected from the backhoe for submittal for chemical analysis. It is anticipated that a minimum of 1 but not more than 2 samples will be collected from each pit for submittal to a laboratory for chemical analysis. The samples for VOCs will not be composited in order to prevent the loss of volatiles. All other samples will be composited in a stainless steel bowl using a stainless steel spatula. Duplicate samples and deionized water trip blanks will also be prepared and submitted for laboratory analysis in accordance with WWES' "Field QC Sample Guidelines" SOP. One duplicate sample will be submitted for every 10 investigative samples. Trip blank samples will accompany each cooler containing VOC samples.

### **2.3.2 LANDFILL COVER EVALUATION**

Measurements of the thickness of the landfill cover will be taken in split-spoon samples collected at each landfill characterization sampling location and at 5 additional locations (total of 8) throughout the landfill. The ultimate locations for collection of landfill cover samples will be selected after the surface geophysical survey has defined the lateral extent of the landfill. Measurements of particle sizes of each landfill cover sample will be performed in accordance with appropriate American Society for Testing and Materials (ASTM) standards. A summary of the number of landfill cover samples to be measured and the specific physical properties to be measured is presented in Table 3. The particle size measurements will be performed by WWES.

## **2.4 HYDROGEOLOGICAL INVESTIGATION**

### **2.4.1 SUBSURFACE SOIL INVESTIGATION**

#### **2.4.1.1 Sampling Locations and Analyses**

Soil samples will be collected at each of the monitoring well locations described in Section 2.4.2 to define the physical characteristics and nature and extent of soil contamination, if any, in the subsurface. Based on the monitoring well locations proposed, it is anticipated that subsurface soil samples will be collected at a minimum of 13 locations and a maximum of 15 locations (see Figure 2).

The 2 northernmost locations are anticipated to lie in areas which have not been affected by landfill activities and are, therefore, anticipated to provide background data essential to evaluating comparatively the results of chemical analyses of soils specific to the site.

#### **2.4.1.2 Sampling Equipment and Procedures**

Documentation of subsurface soil lithologies will be kept in accordance with WWES' "Well Boring/Logging Guidelines" and "Soils Classification" SOP's.

Soil boring samples will be collected through hollow stem augers with a 2-foot long split spoon sampler that has a 3-inch inside diameter using methods described in WWES' "Split-Spoon Sampling" SOP. The 4 locations in the wetlands adjacent to the North Branch of the Kalamazoo River will be sampled using a hand auger.

Split-spoon samples will be collected continuously from the existing ground surface to the top of bedrock at 6 of the locations, (MW-1 through MW-6). At each of the remaining locations, except those within the wetlands, split-spoon samples will be collected at 2.5-foot intervals in the first 10 feet and thereafter at 5-foot intervals to the bottom of the deepest borehole. Continuous sampling will be accomplished with a hand auger at the 4 locations within the wetlands south of the site.

All equipment used for collection of the subsurface soil samples will be decontaminated by washing or steam cleaning in accordance with WWES' "Decontamination, Downhole Sampling Equipment" SOP. Hexane, acetone, and/or methanol will only be used if visible oil or dirt cannot be removed from the sampling equipment by conventional steam cleaning or washing techniques. This will reduce the possibility of introducing volatile contaminants into a sample. The use of hexane, acetone or methanol will be documented on the boring log.

Any boring requiring abandonment will be grouted from the bottom of the borehole to the ground surface with a cement/bentonite grout in accordance with WWES' "Soil Boring Grouting" SOP.

#### **2.4.1.3 Sample Analyses**

At 5-foot intervals during sampling of soils above the water table, qualitative measurements of methane gas emanating from the augers will be taken. The measurements of methane gas will be taken with a methane-specific Draeger tube. Procedures for sampling and measuring for methane will be conducted in accordance with the manufacturers instructions. A headspace analysis will be performed on a portion of each split-spoon sample collected above the water table with a PID or FID in accordance with WWES' SOP, "Jar Headspace Measurements in Unsaturated Soil Samples."

Since monitoring well locations will be selected in areas beyond the extent of impact from landfill activities, based on the surface geophysical survey, no specific subsurface soil samples are anticipated to be submitted for chemical analyses at this time. Upon completion of sampling of subsurface soils during the installation of the 6 initial bedrock monitoring wells described in Section 2.4.2, a determination of the need or benefit of submitting samples for chemical analyses will be made. If deemed necessary, samples from intervals of concern will be collected for submittal to a laboratory from borings drilled during the installation of

monitoring wells in the glacial aquifer. Soil from sampling intervals that register 2 times above the ambient air during screening with the PID, are visibly stained, or have an unusual odor or color will especially be considered for submittal for chemical analyses. Soil samples to be considered for submittal for chemical analyses from remaining locations will be selected in a similar manner. The ultimate decision on whether or not to submit samples for chemical analyses and which samples will be submitted will be made by the U.S. EPA RPM in consultation with the MDNR.

If subsurface soil samples are submitted for chemical analyses, 4 representative soil samples from each soil type encountered at the background locations (MW1 and MW2) will be submitted for the chemical analyses also. It is anticipated 2 soil types will be encountered, therefore; a total of 8 background soil samples would be submitted.

Based on the assumption that the water table will be encountered within 25 feet of the ground surface, it is anticipated that the scope of the subsurface soil sampling may include the submittal of up to 45 investigative samples and 5 duplicates for chemical analysis. Trip blanks (deionized water blanks) will also be prepared and submitted for laboratory analysis in accordance with WWES' "Field QC Sample Guidelines" SOP. Trip blanks will accompany each cooler containing VOC samples. Table 4 summarizes the maximum estimated number of samples submitted and DQO for each chemical analyses.

Any samples submitted for VOC analysis will not be composited in order to prevent the loss of volatiles. All other samples submitted for chemical analyses will be composited in a stainless steel bowl using a stainless steel spatula. The cation exchange capacity (CEC) of samples from soils below the water table at 6 locations (MW-1 through MW-6) will also be measured in accordance with the Region V SAS.

If a clay-rich layer that is greater than 2-feet thick is encountered while drilling, a Shelby tube sample will be collected in accordance with WWES' SOP "Shelby Tube Sampling." Measurements of Atterberg Limits, permeability, and particle size will be taken in accordance with appropriate ASTM methods (D4318, D2434, and D422, respectively) on each Shelby tube sample. It is anticipated that no more than 2 clay layers will be encountered in the 5 borings drilled to the top of bedrock and 1 clay layer will be encountered at each of the remaining 16 locations. These measurements of physical parameters will be conducted by WWES. Table 4 summarizes the estimated number and DQO for each physical parameter measurement.

## **2.4.2 INSTALLATION OF MONITORING WELLS**

A maximum of 37 ground water monitoring wells will be installed at up to 15 tentative locations (see Figure 3) during Phase I of this RI. At some of the locations it is possible that no wells will be installed. A summary of all proposed and optional wells at each location is provided in Table 5. The ultimate determination of the number of wells required to define ground water flow and quality characteristics will be based on results of the geophysical survey and after 6 of the initial monitoring wells have been installed and preliminary ground water data are available. A flow chart for criteria used to determine the number of bedrock monitoring wells ultimately installed during Phase I is provided in Figure 4. The number of monitoring wells installed in the glacial deposits will be dependent on the number of locations at which bedrock wells are installed and the thickness of the glacial aquifer.

Based on results of field screening and the downhole geophysical survey, optimal well screen placement will be determined. It is anticipated that 1 well at each location will be screened immediately below the top of the water table. Other wells may be installed immediately above the bedrock and/or in the bedrock.

Initially, the bedrock wells at 5 locations (MW-1 through MW-5) will be installed. Upon completion, the top of casing elevation of each monitoring well will be surveyed in accordance with WWES' "Elevation Surveys for Monitor Wells" SOP. Water levels will be collected in accordance with WWES' "Water Level Measurements" SOP. Based on the calculated ground water flow direction resulting from measurements made in these 5 wells, the deep bedrock well at MW-6 will be installed directly downgradient from the site.

Two well clusters will be installed upgradient of the landfill (MW-1 and MW-2). These clusters will be located on privately owned property and U.S. EPA assistance will be sought in obtaining permission to install these, and other off-site wells, at suitable locations.

The deepest well will be drilled at each cluster location first. Soil sampling of unconsolidated materials will be accomplished with a split-spoon sampler and Shelby tubes as described in Section 2.4.1 above. Sampling of bedrock will be performed as described in Section 2.4.4. Because of the proximity of the wells within a cluster, it will be unnecessary to sample and describe the lithology of each borehole during the installation of each well in a cluster. Therefore, the glacial materials in only one borehole of each well cluster will be sampled and described in detail. Installation of wells in glacial deposits will occur after installation of bedrock wells at MW-1 through MW-6 is complete.



All drilling and well installation will be supervised and documented by qualified WWES personnel. Documentation will be recorded on boring log forms in accordance with WWES' "Field Notes/Records" and "Well/Boring Log Guidelines" SOP's. All drilling equipment including the drilling rig, augers, tools, and other necessary materials will be washed or steam cleaned between each borehole in accordance with WWES' "Decontamination, Downhole Sampling Equipment" SOP. Hexane, acetone, and/or methanol will only be used if visible oil or dirt cannot be removed from the sampling equipment by conventional steam cleaning or washing techniques. This will reduce the possibility of introducing VOCs into a sample. The use of hexane, acetone or methanol will be documented on the boring log.

All monitoring wells will be constructed of 2-inch diameter PVC riser pipe and screens with flush joint threads. The use of PVC for well materials will allow electromagnetic geophysical logging of any well to evaluate ground water quality as described in Section 2.4.2.4. Threaded joints between sections of casing will be wrapped with Teflon tape to eliminate leakage at the threads. The screens will have 0.010-inch (10-slot) factory prepared slots. A threaded PVC cap will be installed on the bottom of each well screen. Prior to installation of each well, all well construction materials will be steam cleaned to the satisfaction of WWES personnel.

A sand pack of clean silica sand shall be placed in the screened interval and extend to at least 2 feet and not more than 3 feet above the top of the well screen. A 2 to 3-foot thick seal of granular or pelletized bentonite will be emplaced immediately above the top of the sand pack to ensure that a competent seal is in place. A cement/bentonite grout will be tremied from the bentonite seal to just below ground surface to ensure that the annular space between the well and borehole has been completely sealed. A locking, steel, protective casing will be installed at the ground surface secured in concrete. Steel bumper posts may be installed surrounding any well that appears to be in a traffic zone. All borehole drilling and well construction details will be recorded by WWES personnel in a bound field logbook or on boring log and well installation data sheets. A schematic diagram of construction details for monitoring wells in glacial deposits and monitoring wells in bedrock is shown in Figures 5 and 6, respectively.

Each of the monitoring wells will be developed no earlier than 24 hours after installation. Well development will be done by a method which will result in surging and pumping water back and forth through the well screen in accordance with WWES' "Monitoring Well Purging With a Bladder, Keck, or Electric Submersible Pump" or "Monitoring Well Purging with a Suction Ditch Pump" SOPs. The wells will be developed until at least 3 to 5 well

volumes have been evacuated and pH, temperature, and specific conductivity measurements have stabilized to within 10 percent for two successive well volumes. The pH and conductivity in each sample will be measured in accordance with WWES' "Standard Operating Procedure for Field Determination of pH" and "Standard Operating Procedure for Field Determination of Conductivity, Method 205" SOPs, respectively. Well volumes will be calculated in accordance with WWES' "Well Casing Volume Calculation" SOP. Purged water will be containerized in 55-gallon drums for storage until the ground water analytical results can be reviewed. The drums will be labeled according to which well the water was collected and stored within a secured area until their ultimate fate can be determined. All details concerning well development including date, time, method and amount of water evacuated will be recorded by WWES personnel in a bound field logbook or on well data sheets.

During Phase II of this RI, as many as 12 contingency wells (5 in the glacial materials, 5 in the shallow bedrock, and 2 deep bedrock) may be drilled for plume definition purposes at locations to be determined based on results of the Phase I investigations. Twelve contingency wells have been budgeted for this purpose. These wells will only be installed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer.

#### **2.4.2.1 Monitoring Wells in Glacial Deposits**

Only 1 well is proposed at each of the 4 locations adjacent to the North Branch of the Kalamazoo River since each lies within a wetland area and the water table is anticipated to be shallow in this area.

One monitoring well will be installed at each of the 4 locations in the wetlands along the North Branch of the Kalamazoo River. Each of these wells will have a 3-foot long screen which will be installed approximately 2 feet below the water table. These wells will be installed in hand-augered boreholes. Since ground water at these locations is anticipated to be near the ground surface, and at times, exhibit artesian conditions, each of these well casings will be equipped with packer inside the casing. The packer will provide a means of depressing, and holding, the ground water level below the frost line during the winter to prevent the water from freezing and potentially cracking the well casing.

All other monitoring wells installed in the glacial deposits will be installed through hollow stem augers in accordance with the methods described in WWES' "Installation of Permanent Monitoring Wells with Hollow Stem Augers" SOP. The minimum inside diameter of the

hollow stem augers will be 4.25 inches. Except at the wetland locations discussed above, it is anticipated that 2 monitoring wells with 5-foot long screens will be installed in the glacial deposits at each location. One monitoring well will be installed with the top of the screen set approximately 2 feet below the water table, and 1 will be installed with the base of the screen immediately above the top of bedrock. If the glacial aquifer is no more than 15 feet thick, only 1 monitoring well will be set in the glacial deposits. Placement of the screens in the glacial aquifer may also depend on results of the downhole geophysics and the vertical ground water sampling.

#### **2.4.2.2 Monitoring Wells in Bedrock**

The top of the screen in all bedrock wells, except the deep well at the downgradient location (MW-6), will be installed approximately 10 feet below the top of the unweathered bedrock. The screens in all bedrock wells will be 5 feet long. The screen at the downgradient location will be set in the second 10-foot interval of bedrock in which no evidence of contamination is observed, in the field, as described in Section 2.4.4.3.

The glacial materials at each bedrock well will be cased with 6-inch diameter PVC set through 8.25-inch hollow stem augers in essentially the same manner as described in Section 2.4.2.1 for installing wells through hollow stem augers. The casing will extend 2 feet below the base of the unweathered bedrock. A packer will be installed on the bottom of the casing to aid in sealing the annular space between the casing and the borehole with a cement/bentonite grout. The cement/bentonite grout will be allowed to set for a minimum of 24 hours before drilling activities resume.

At the first 6 bedrock locations drilled, the bedrock will be cored using air rotary drilling techniques as described in Section 2.4.2.3. Upon completion of coring, the boreholes will be reamed to approximately 6 inches in diameter then flushed with water to clean the borehole prior to installing the well. Air rotary techniques will be used to drill the 6-inch diameter boreholes for each of the remaining bedrock wells. Two-inch diameter PVC wells will then be installed in each borehole. Essentially all other well installation details will be as described in Section 2.4.2.1 for installing wells through hollow stem augers.

The compressed air used for drilling will be filtered to prevent the introduction of water, oils, or any other foreign substance downhole and into the subsurface.

#### **2.4.2.3 Bedrock Coring**

Cores will initially be collected in 5-foot intervals. Coring intervals may be increased to 10 feet if core recovery is consistently greater than 95 percent. Core samples will allow for examination of consolidated rock samples which will aid in defining lithologic and physical characteristics of the bedrock. The presence of bedding, joints, fractures, and other structural features of the bedrock will be documented. The depths and character of each stratum encountered in the borehole will be recorded, along with notations of other visually apparent features such as fractures, joints and other physical features, on the well/boring log.

The core samples will be placed in order of collection, from top to bottom, in wooden boxes for storage on-site. The top and bottom of each core will be labeled at the time of collection and spacers marked with sample depths will be placed between each core sample. Samples in each core box will be photographed.

#### **2.4.2.4 Downhole Geophysical Logging**

A suite of geophysical logs will be run in PVC-cased wells penetrating shallow bedrock at locations MW-1 through MW-5 and in the deep bedrock well at location MW-6 (see Figure 3). The suite will include natural gamma and EM conductivity logs which will be used to delineate lithology and to evaluate ground water quality.

The gamma log measurements will be made in accordance with WWES' "Borehole Geophysical Logging (Gamma)" SOP using a Keck SR-3000 Borehole Logger (or equivalent) designed to detect gamma radiation emitted primarily from the isotope potassium-40. These natural emissions are indicative of relative clay content and will allow identification of clay layers or clayey zones which may affect ground water flow and thus contaminant migration pathways. Time constant and logging speed will be selected to provide vertical resolution on the order of 0.5-foot.

A Geonics EM-39 Borehole Logger (or equivalent) will be used to measure vertical variations in pore fluid conductivity at a distance of 12-inches from the borehole axis. The EM conductivity logs will be obtained in accordance with WWES' "Borehole Geophysical Logging (EM-Induction)" SOP. This data will allow vertical definition of a conductive contaminant plume, if present. These data, collected from the bedrock wells, can be used to determine the appropriate screen depth for the monitoring wells set in the glacial deposits.

### **2.4.3 GROUND WATER FLOW CHARACTERISTICS**

#### **2.4.3.1 Aquifer Tests**

An *in situ* hydraulic conductivity test (slug test) will be performed on each monitoring well installed during Phase I of the RI in accordance with WWES' "Slug Tests" SOP. Data obtained from the slug test will be evaluated using the computer program AQTESOLV based on Bouwer and Rice, 1976, Bouwer 1989, and Cooper, Bredehaft, and Papadopoulos, 1967.

*In situ* hydraulic conductivity tests (packer tests) will be performed in the bedrock corehole at the downgradient monitoring well location (MW-6). The packer tests will be performed on the entire cored interval and the tests and data evaluation will be performed in accordance with methods described in Test Designation E-18 of the Earth Manual (Bureau of Reclamation, 1974). This test method is provided in Appendix C.

The packer tests will be performed in 10-foot intervals from the bottom of the borehole to the top of bedrock. If the hydraulic conductivity within a test interval is too high to obtain meaningful data, the test may be rerun in that zone in 5-foot intervals. The packers will be inflated with nitrogen gas to eliminate the potential for influencing subsurface chemistry if a leak were to develop in the supply line or packers.

If results of other field investigations conducted during this RI do not define the degree of communication between the glacial and bedrock aquifers, it may be necessary to perform a pump test on one or both of the aquifers. The necessity of a pumping test as well as the pumping test design and analysis, will be determined with concurrence of the U.S. EPA in consultation with the MDNR.

#### **2.4.3.2 Ground Water Flow Direction**

On 3 occasions prior to completing modeling described in Section 2.4.3.3, ground water level measurements will be taken in each of the monitoring wells installed during Phase I of this RI in accordance with WWES' "Water Level Measurements" SOP. Surface water elevation measurements will also be taken on each occasion at staff gauges installed both upstream and downstream from the site in the North Branch of the Kalamazoo River. Water levels will be measured in all wells within a 24-hour period on each occasion. The rounds of water levels will be separated by a minimum period of four weeks.

Surface water flow in the North Branch of the Kalamazoo River will also be measured during the first and third water level measuring occasions. River flow measurements will be taken in accordance with WWES' "Surface Water Flow Measurements" SOP.

Water levels and surface water flow measurements will aid in defining ground water flow characteristics beneath the site and in assessing the hydraulic connection between the glacial and bedrock aquifers, and the North Branch of the Kalamazoo River. These measurements will also aid in accurately calibrating ground water models used during this RI to site specific conditions. Water level measurements will be taken on a monthly basis throughout the initial year of the RI/FS.

#### **2.4.3.3 Ground Water Modeling**

It is anticipated that ground water flow modeling will be necessary in order to evaluate the potential remedial options, ground water flow patterns, and exposure routes at the site.

To achieve these objectives, we anticipate using a three-dimensional flow model finite-difference computer code developed by the U.S. Geological Survey entitled MODFLOW. Various preprocessors and post-processors will be applied in conjunction with MODFLOW. The modeling will be conducted in accordance with WWES' "Numerical Ground Water Modeling" SOP. The numerical model will incorporate the site hydrogeology determined by results of the field investigations to mathematically represent flow within the aquifers and the hydraulic communication with the North Branch of the Kalamazoo River.

The integrity of the model will be assured by calibrating the modeled water levels with the actual water levels measured at monitoring wells in the field. Calibration will consist of adjusting the hydraulic parameter values that are input into the ground water model. Reasonable ranges for the hydraulic conductivity of distinct units, the rate of recharge, and the riverbed conductance will be established on the basis of the geologic environment and the data collected. Within the stated range, the value of input parameters will be varied until a combination is attained that minimizes the difference between the modeled and actual values of water levels. The calibration will be performed on the set of observed water levels that best approximate average conditions.

Once calibration has been completed, the output of the numerical model (nodal values for hydraulic head) will be combined with hydraulic conductivity values and boundary conditions to determine expected flow lines and times of travel.

The model will have the capacity to test the effect of potential remedial options (for example, recovery wells, trenches, slurry walls) and if ground water treatment includes purging, to provide estimates of the time required for different constituents of concern.

#### **2.4.4 GROUND WATER SAMPLING**

##### **2.4.4.1 Ground Water Sampling Locations and Parameters**

Two ground water samples will be collected at each monitoring well in order to evaluate the impact of the landfill on the aquifers beneath the site. The proposed monitoring well locations are illustrated in Figure 3. The monitoring wells will be installed as described in Section 2.4.2. Installation and development activities will be completed at least 72 hours before ground water sampling activities commence at each well. Up to 37 monitoring wells may be installed and sampled at the site.

Ground water samples will be collected on 2 occasions from each monitoring well and submitted for chemical analyses as summarized in Table 6. The results of the first set of analyses will be evaluated to determine which samples from the second set should be submitted using the low detection limit residential well Special Analytical Services (SAS) request. Ground water which, based on the first analytical set, has very low or detectable levels of Target Compound List (TCL) organics and TAL inorganics, will be selected for the SAS analysis during the second set of analyses. This will allow for screening for compounds at lower detection limits to achieve compliance with Michigan Act 307 detection limit requirements.

##### **2.4.4.2 Ground Water Sampling and Equipment Procedures**

Ground water samples will be collected using a Teflon bailer following WWES' "Monitoring Well Sampling with a Bailer" SOP. To prevent the loss of contaminants while sampling, a bottom-emptying device will be utilized on the bailer when collecting samples to be analyzed for organics. Shallow monitoring wells will be purged prior to sampling with a clean Teflon bailer. In the deeper monitoring wells, purging prior to sampling with the bailer will be accomplished using a Keck pump following WWES' "Monitoring Well Purging with a Bladder, Keck, or Electric Submersible Pump" SOP. All wells will be purged of at least 3 casing volumes prior to sampling. Upon completion of purging, the temperature, pH, specific conductivity, and Eh of each sample will be measured. Measurements of the pH, specific conductivity, and Eh of each sample will be measured in accordance with WWES' "Field Determination of pH", "Field Determination of Specific Conductivity, Method 205",

and "Field Determination of Oxidation/Reduction Potential (Eh)" SOPs, respectively. Samples collected for analysis of TAL metals will be filtered at the time of collection using a 0.45-micron membrane filter. Samples collected for analysis of TAL cyanide will not be filtered. All sampling equipment will be decontaminated between use following WWES' "Decontamination Down-hole Sampling Equipment" SOP.

#### **2.4.4.3 Vertical Ground Water Sampling**

Ground water samples will be collected from the bedrock aquifer during coring of the deep bedrock well (MW-6) at the downgradient location. Samples will be collected for each 10-foot interval cored. After a 10-foot interval of rock has been cored, that section of bedrock will be isolated by using a packer at the top of the interval. At least three 10-foot corehole volumes will be purged from the sampling interval prior to sample collection. Specific conductivity, temperature, and pH will be measured periodically while purging to document that these parameters have stabilized prior to collecting a sample. Measurements of the pH, Eh, temperature, and specific conductivity will be taken, and a scan for volatile organic compounds listed in Table 7 will be performed with a gas chromatograph (GC) at the time each sample is collected. If the field measurements or GC scan indicate evidence of contamination is present, coring will continue. If no contamination is detected with these field analyses in 2 successive 10-foot rock intervals, or the corehole has been sampled to a depth of 120 feet, coring will cease and a well will be set as described in Section 2.4.2.2.

Ground water samples will be collected at 5-foot intervals while drilling through glacial deposits at 3 locations, (MW-3, MW-4, and MW-6) during installation of the 6 initial bedrock monitoring wells. Sampling will be accomplished through temporary monitoring wells in accordance with WWES' "Temporary Wells Through Hollow Stem Augers" SOP.

Measurements of pH, Eh, temperature, and specific conductivity will be taken in the field, and a field scan for VOCs will be performed with a GC at the time each sample is collected. The field scan for VOCs will include the parameters listed in Table 7. Scanning will be performed in accordance with WWES' "Field Analyses for Volatile Organics in Ground Water" SOP.

### **2.5 SURFACE WATER INVESTIGATIONS**

Twelve surface water samples will be collected from the North Branch of the Kalamazoo River. Six samples (3 pairs) will be collected from areas downstream of the site and six samples (3 pairs) will be collected from upstream areas. Eight surface water samples will be



collected from wetland areas adjacent to the river, 4 from upstream wetlands and 4 from downstream wetlands. Four surface water samples will also be collected (if possible) from wetlands north of Erie Road. These surface water sampling locations are shown on Figure 7. The locations of these samples may be revised following review of the ground water flow direction.

Surface water samples from the river will be collected in midstream/nearshore pairs. The midstream location is identified as one-half the shortest transect of the stream at the sampling location. The nearshore location is identified as 2 feet from the left bank of the river (facing upstream) along the same transect. The locations of these transects are presented in Figure 7. The nearshore samples will be collected from depths 1 foot below the surface, unless the water is found to be less than 1.5 feet in depth. In this case, the sample will be collected from the depth one-half the distance from the surface to bottom. Samples from midstream will be collected from a depth equal to 60% of the total depth at the sample location. Samples will be collected directly into the sampling bottle. In shallow water, the samples will be collected by a field technician wearing waders and shoulder length gloves. The technician will stand downstream of the station and collect the sample to the upstream side. If deeper water is encountered, it may be necessary to collect samples from a boat. Both unfiltered and filtered surface water samples will be collected for TAL metals analysis. Surface water samples for TAL cyanide analysis will not be filtered. A 0.45 micron membrane filter will be used to filter the samples. Surface water samples will be collected in accordance with WWES' "Surface Water Sampling" SOP.

River water samples will be collected beginning at the furthest downstream station and proceeding upstream. Samples will be collected on a day when the stream level is in static conditions (neither rising or falling significantly) and at least 48-hours following the last precipitation event. All surface water samples will be collected on the same day to minimize effects due to changing water conditions.

Just prior to river water sampling, river flow measurements will be taken at the Twenty-nine and One-Half Mile Road bridge, approximately 0.5 miles downstream of the site. River flow will be measured in accordance with WWES' "Surface Water Flow Measurements" SOP.

Surface water samples in wetlands will be collected at depths midway between the water surface and bottom. Samples will be collected directly into the sampling bottle. In the case of VOCs, the VOC vial will be pre-preserved. The sample will be collected by a field technician wearing waders and shoulder length gloves.

Duplicate samples and deionized water trip blanks will also be prepared and submitted for laboratory analysis. One duplicate sample will be submitted for every 10 investigative samples. Trip blank samples will accompany each cooler containing VOC samples.

At each river and wetland sampling location, field measurements of pH, dissolved oxygen, specific conductivity, Eh, and temperature will be taken. These WWES SOPs are included in Appendix A. Table 8 summarizes the maximum estimated number of samples submitted and DQO for each chemical analysis.

## **2.6 SEDIMENT INVESTIGATIONS**

Twelve sediment samples will be collected from the North Branch of the Kalamazoo River. These will be collected from the same locations as surface water (i.e., 6 samples will be collected upstream and 6 samples will be collected downstream of the site). These samples will also be collected in midstream/nearshore pairs. Midstream and nearshore samples will be identified as discussed for surface water above. Eight additional sediment samples will be collected from the wetland areas adjacent to upstream and downstream areas of the river. In addition, four sediment samples from wetland areas north of Erie Road, west and east of the site, will also be collected. The proposed sampling locations are shown in Figure 7. It may be necessary to move the stations slightly from these indicated positions depending on field conditions.

Sediment samples will be collected from the river using a Petite Ponar sampler. In shallow water, the sampler will wade to the sampling point. If deeper water is encountered, it may be necessary to collect samples from a boat. In either case, samples will be collected beginning with the downstream locations and proceeding to upstream sampling locations. Sediment samples from the river will not be collected on the same day as surface water samples. The samples for VOCs will not be composited in order to prevent the loss of volatiles. All other samples will be composited in a stainless steel bowl using a stainless steel spatula.

Sediment samples will be collected from wetland areas using either a stainless steel shovel or a Petite Ponar sampler. In wetlands, surface water and sediment samples will be collected at each station during the same visit (the surface water sample will be collected first followed by the sediment sample). Sediment samples will be collected from the top 0 to 12 inches of sediment beneath any vegetative mat. Sediment clinging to the mat will be scrapped off into the area to be sampled. Table 9 summarizes the maximum estimated number of samples

submitted and DQO for each chemical analysis. Any free water on top of the sediment samples will be decanted from the sample before the sample is placed in sample containers.

Duplicate samples and trip blanks (deionized water blanks) will also be prepared and submitted for laboratory analysis. One duplicate sample will be prepared for every 10 investigative samples. Trip blank samples will accompany each cooler containing VOC samples.

A specific description of standard sediment sampling procedures to be used is documented in WWES' "Surficial Sediment Sampling" SOP.

## **2.7 RESIDENTIAL WELL SAMPLING**

### **2.7.1 SAMPLE LOCATIONS AND ANALYSES**

Up to 20 private wells will be sampled in the area surrounding the Albion-Sheridan Township Landfill. The selection of individual wells to be sampled will be dependent on the ground water flow direction and the proximity of the wells to the Albion-Sheridan Township Landfill.

Duplicate samples and deionized water trip blanks, will also be prepared and submitted for laboratory analysis. Trip blank samples will accompany each cooler containing VOC samples.

### **2.7.2 SAMPLING EQUIPMENT AND PROCEDURES**

U.S. EPA, MDNR, and/or Calhoun County will assist WWES in obtaining permission and scheduling the sample collection. The samples will be collected according to WWES' "Sampling Ground Water from a Domestic Well" SOP. The SOP specifies that samples be collected directly from a tap that intercepts the water system prior to any treatment, such as a water softening unit. The water will be allowed to run for at least 15 minutes to ensure that the pipes have been adequately flushed. The flow will be measured and recorded. The water samples will be collected directly from the tap into the appropriate sample bottles. Water will be introduced slowly into VOC vials to reduce splashing and volatilization. Samples will not be field filtered.

Field measurements for the water samples that will be recorded in a logbook or on field data sheets include; pH, Eh, specific conductivity, and temperature. Additional data that will also be noted include; color of sample, any odors, amount of time the pipes were flushed, details

concerning well system, piping and proximity to septic system. Table 10 summarizes the maximum estimated number of samples submitted and DQO for each chemical analyses.

## **2.8 SURFACE SOIL INVESTIGATION**

### **2.8.1 SAMPLING LOCATIONS AND ANALYSIS**

Surface soil (0 to 6 inches) will be collected at several locations in and around the landfill to evaluate surface soil contamination.

An estimated 12 to 16 surface soil samples will be collected at areas of special concern. These areas will include the former refuse transfer station on the north side of the site, areas where drums were previously located, the ORV area west of the site, and the residential area and garden on the southern portion of the site. The selection of the exact locations for these samples will be based on visual observations, including, but not limited to, soil staining and noticeable odors. Sampling locations will be approved by the U.S. EPA.

Background surface soil samples will be collected from 4 sampling locations for each surface soil type identified in on-site sampling. In identifying suitable background sampling locations, areas unaffected by the site (upgradient and upwind) will be selected. This is most likely to be an area north of the site. The area selected for background sample collection will be located at least 100 feet from any roads, roadsides, parking lots, railroads, storm drains or areas visibly appearing to be affected by the site.

Duplicate samples and deionized water trip blanks will also be prepared and submitted for laboratory analysis. Trip blank samples will accompany each cooler containing VOC samples.

### **2.8.2 SAMPLING EQUIPMENT AND PROCEDURES**

The samples will be collected using a decontaminated stainless steel spatula, hand auger, or trowel. The soil will be immediately transferred into the appropriate jars to reduce the loss of VOCs. The remaining soil will be mixed and then will be transferred to the appropriate sample container. The samples will be collected from between 0 to 6 inches below the ground surface. The specific area in which the samples will be collected will be determined in the field after examination of current field conditions. The samples for VOCs will not be composited in order to prevent the loss of volatiles. All other samples will be composited in a stainless steel bowl using a stainless steel spatula. The surface soil sampling equipment

will be decontaminated with an alconox or TSP wash solution, a rinse of tap water, and a final rinse in distilled water between each sample. Hexane will only be used if visible oil or dirt cannot be removed by conventional decontamination techniques. This will reduce the possibility of introducing volatile contaminants into the sample. The samples will be visually described and scanned with an PID and/or FID.

All details concerning the surface soil samples will be documented in a bound field logbook or field data sheets. The sampling locations will be tied into the site grid.

A specific description of standard surface soil sampling procedures is presented in WWES' "Grab Samples of Surface Soils" SOP. Surface soil samples will be analyzed for the list of analytes presented in Table 11.

## **2.9 ECOLOGICAL INVESTIGATIONS**

Biological and ecological information will be collected at the site and used as part of the Baseline Risk Assessment. Information for this assessment will be derived from a combination of existing information and RI field investigations. Phase I and potential Phase II activities are described below.

### **2.9.1 PHASE I ECOLOGICAL ASSESSMENT**

The Phase I Ecological Assessment will include an evaluation of the following: previously collected regional information on habitats and species of concern; recorded observances of terrestrial species on the site during RI activities; identification of dominant plants and plant communities; and media-specific data collected during the sediment, surface water, and ground water investigations.

To identify the habitats and species of concern, the MDNR and the U.S. Fish and Wildlife Service will be contacted in writing and requested to provide information from past surveys in the area. This will include information from the Michigan Natural Features Inventory concerning threatened and endangered species. To further document species of concern, a record of terrestrial animals observed on-site during the RI will be maintained. This record will be kept during three distinct investigation phases which include: the wetland sampling event, the surface water sampling event, and the surface soil sampling event. In addition, dominant plant species and communities and potential areas of floral stress at the site will be recorded.

A toxicity assessment will combine information on habitats and species of concern with the results of sampling of the various environmental media. The toxic impacts of site related chemicals on the nearby river will be estimated by comparing surface water and sediment concentrations to available surface water and sediment criteria. This assessment may also utilize the site ground water model to estimate contaminant loads to the river under reasonable worst case conditions. These predicted concentrations would then also be compared to available surface water and sediment quality criteria.

## **2.9.2 PHASE II ECOLOGICAL ASSESSMENT**

The above information will be summarized in a Preliminary Ecological Investigation Report. This document will be sent to U.S. EPA for review and comments on this document and will be used as the basis for potential Phase II ecological sampling. If the preliminary investigation warrants, Phase II biological sampling will be conducted. A possible focus of Phase II biological sampling would be benthic macroinvertebrates in the nearby river. Other potential tasks may include aquatic or sediment, chronic or acute toxicity testing, bioaccumulation studies, or community studies. This work will only be performed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer.

## **2.10 AIR MODELING (OPTIONAL)**

If determined to be necessary based on the results of other site investigations, several U.S. EPA-approved predictive models, including CHEMDAT7, BOXMOD, and ISCST, may be used to estimate concentrations of chemicals in the ambient air on and near the site. This work will only be performed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer. Air modeling will be conducted to support the analyses contained in the Baseline Risk Assessment for the site. Direct monitoring of air contaminants will not be conducted during the Phase I investigation.

The predictive models to be employed require information on source areas (contaminated soils) presented in square grids. Contaminant soil concentrations and soil characteristics in source areas to be used in the air modeling will be determined from the surface and subsurface soil investigations described in Sections 2.4.1 and 2.8 of this plan. Model inputs will be based on soil samples collected from all depths within specific source areas. Meteorological data, including wind speed and direction, are inputs to these models and will be obtained from the nearest National Weather Service (NWS) air monitoring stations

(Jackson or Battle Creek, Michigan). Physical data for modeled chemicals will be obtained through databases developed by U.S. EPA for use in the above models.

## **2.11 SOIL VAPOR SURVEY (OPTIONAL)**

### **2.11.1 SOIL VAPOR SAMPLE LOCATIONS**

If results of other field activities of the RI deem that it is appropriate, a soil vapor survey will be conducted at the site. This work will only be performed if approved by the U.S. EPA RPM and authorized by the U.S. EPA Contracting Officer. A soil vapor survey may aid in 1) determining the organic composition of the soil vapor; 2) locating potential source areas for volatile organic compounds (VOCs) within the landfill; and 3) delineating the horizontal extent of VOCs within the unsaturated zone at the site.

The decision on the necessity and objectives for a soil vapor survey will be made with direction from the U.S. EPA. Details such as the number of sample locations, appropriate sampling depths and sampling location selections will be determined once an objective has been defined.

Any soil vapor samples collected will be analyzed for the volatile organic compounds identified in Table 7. All analyses will be performed in the field using a Hewlett Packard 5890A GC or equivalent. The analysis will be conducted according to WWES' "Field Analyses of Soil Vapor for Volatile Organic Compounds" SOP. Any deviations from these SOPs will be documented in the field notes and evaluated during the interpretation of the results. The DQO for the analyses is a Level II.

### **2.11.2 SOIL VAPOR SAMPLING PROCEDURES**

If a soil vapor survey is conducted, a decontaminated, heavy-duty alloy steel soil vapor probe, with a stainless steel mini-well casing will be installed at each sampling location using a hydraulic probe driving unit. The mini-well casing will be decontaminated by first brushing off any visible dirt with a stiff wire brush, the casing will then be steam cleaned, securely wrapped in clean plastic, and then stored away from possible contaminants until needed at a sampling location. Prior to sample collection, the probe will be purged with a low volume air pump until 3 times the volume of the soil vapor probe is evacuated from the probe. The air pump will be calibrated in accordance with the procedures documented in Appendix D. While the probe is being purged, VOC readings will be made with a photoionization detector (PID) and/or flame ionization detector (FID) for health and safety

purposes and to assess if the total organic vapor concentration of the soil vapor changes with time. After purging, the soil vapor samples will be collected into a Tedlar bag.

The Tedlar bag will be filled by connecting the bag with a Teflon-lined sampling liner to the soil vapor probe and inducing a vacuum on the exterior of the bag, which will directly draw the soil vapor into the bag as illustrated in Figure 8. The Tedlar bag will be used to directly inject the sample into a Hewlett Packard-GC, located on-site. The Hewlett Packard-GC will be operated in accordance with WWES' "Field Analysis of Soil Vapor for Volatile Organics Compounds" SOP.



### **3.0 REFERENCES**

ASTM, 1992, Annual Book of ASTM Standards, Section 4, Vol. 04.08.

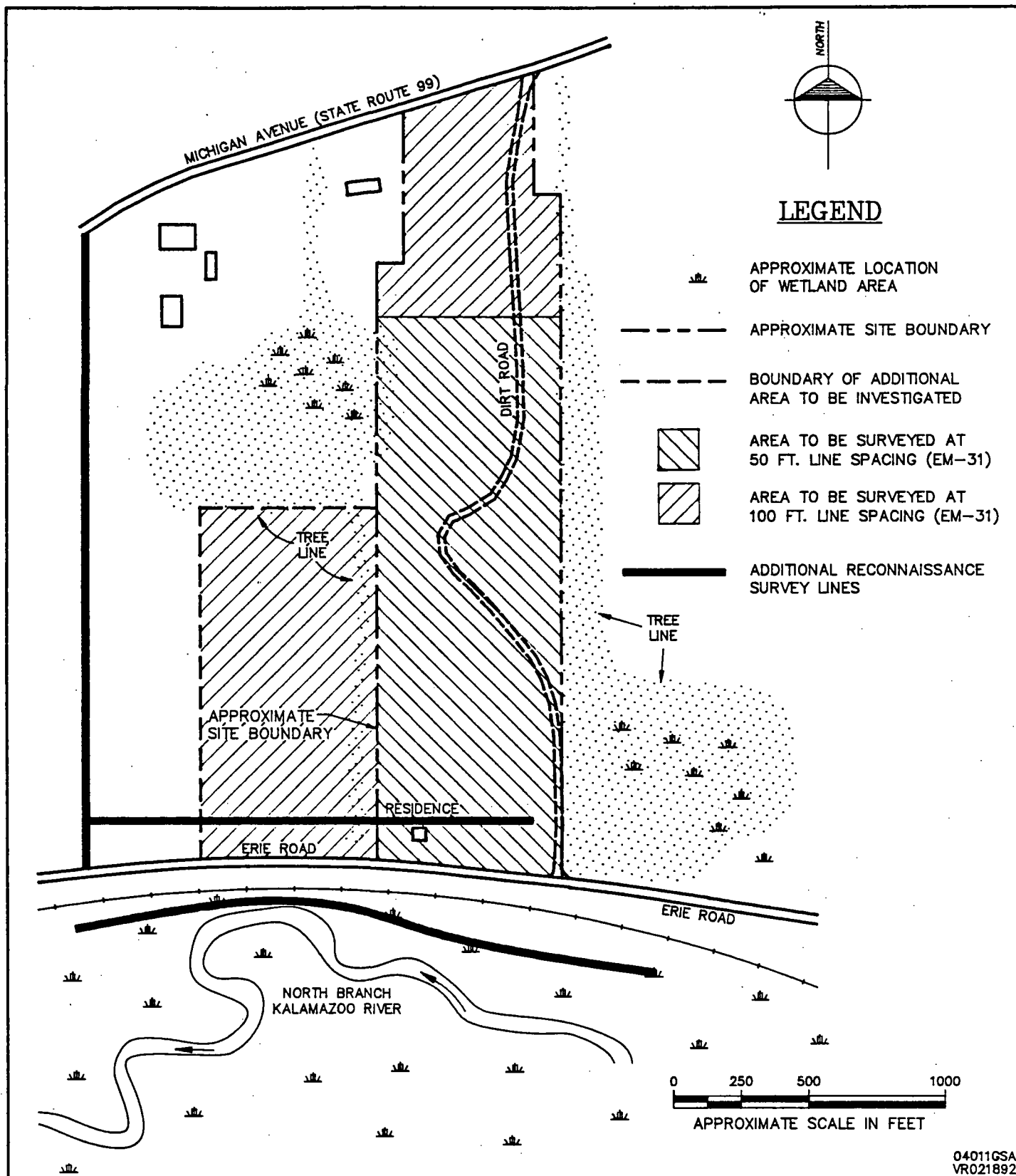
Bouwer, H. May-June, 1989. The Bouwer and Rice Slug Test--An Update. "Ground Water", Vol. 27, No. 3, pp. 304-309.

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Cooper, H.H., J.D. Bredehoeft, and S.S. Papadopoulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Charge of Water. "Water Resources Research", Vol. 3, No. 1, pp. 263-269.

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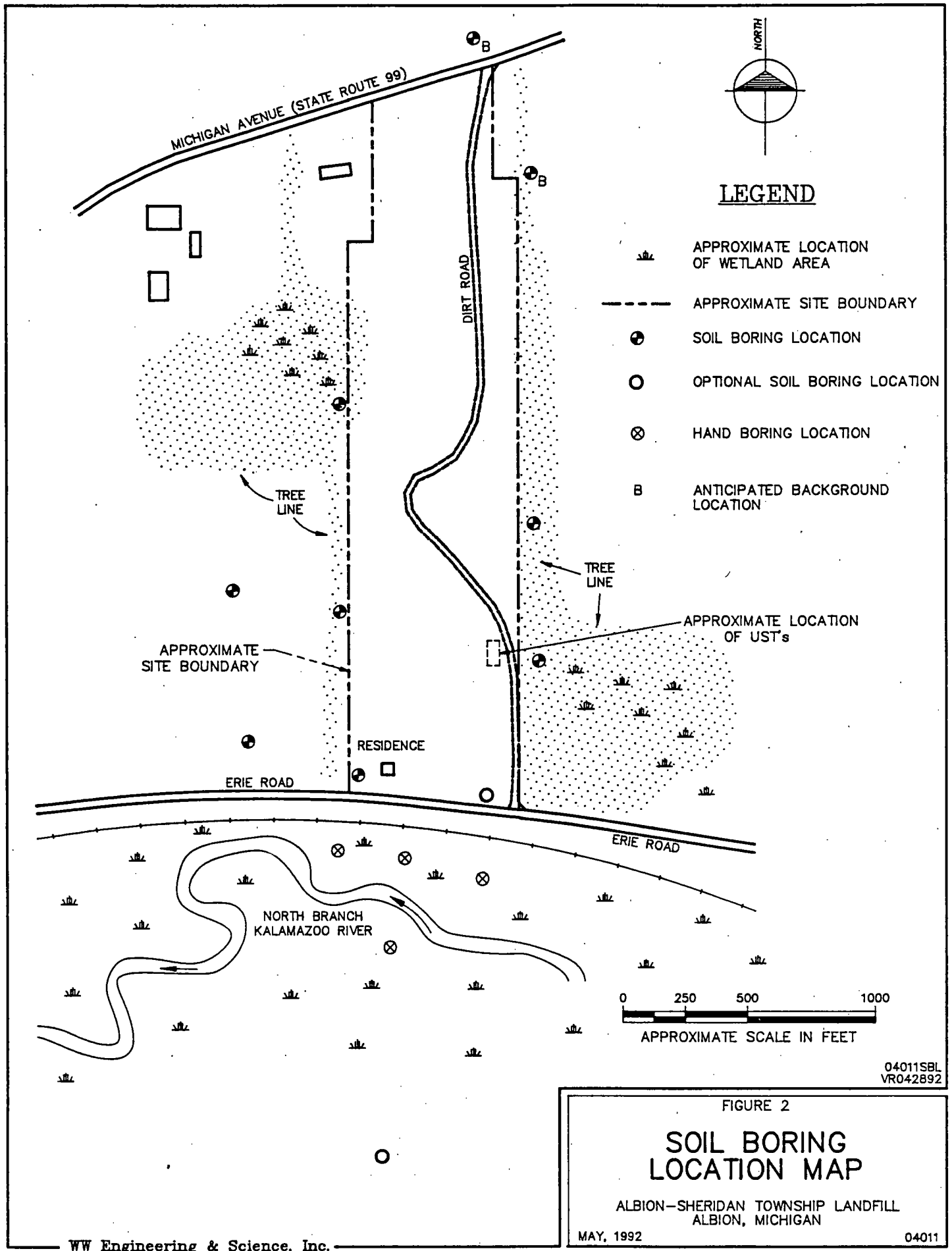
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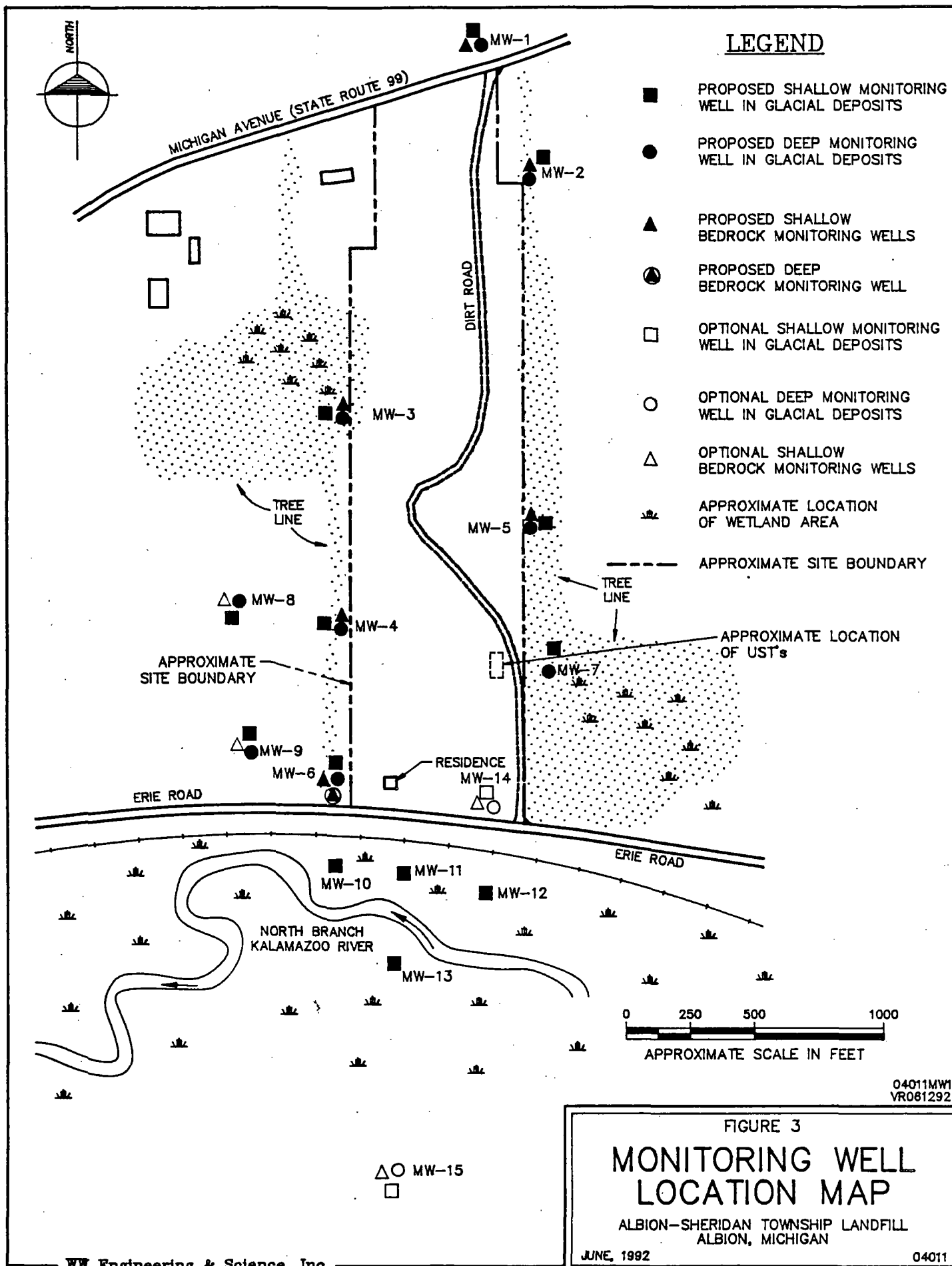
FIGURE 1  
**GEOPHYSICAL SURVEY  
AREA**

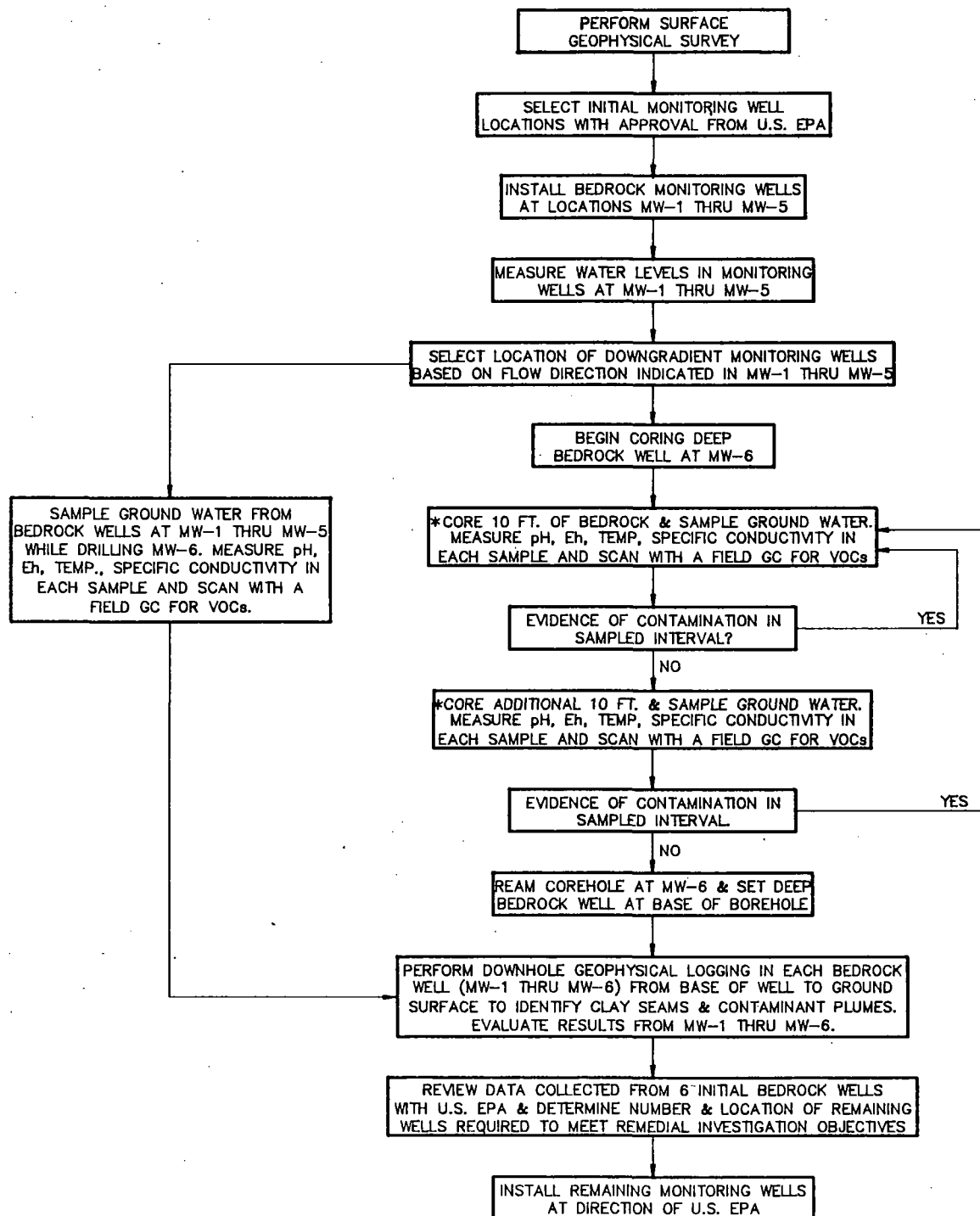
ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

FEBRUARY, 1992

04011







\* NOTE: MAXIMUM DEPTH OF MW-6 IS 120 FEET.

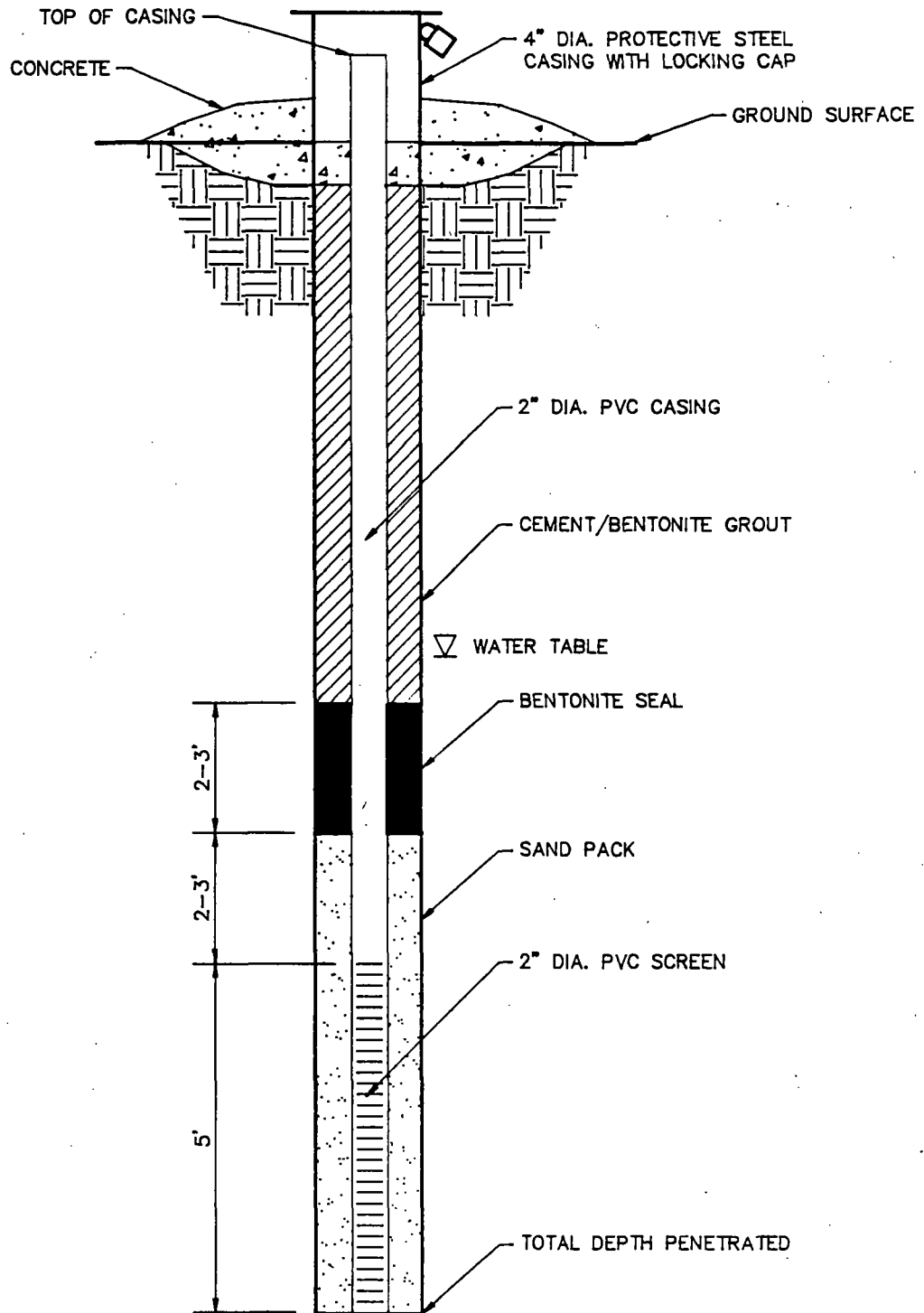
04011-FC  
LVP050492

FIGURE 4  
**FLOW CHART FOR  
BEDROCK MONITORING  
WELL INSTALLATION**

ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

MAY, 1992

04011.01



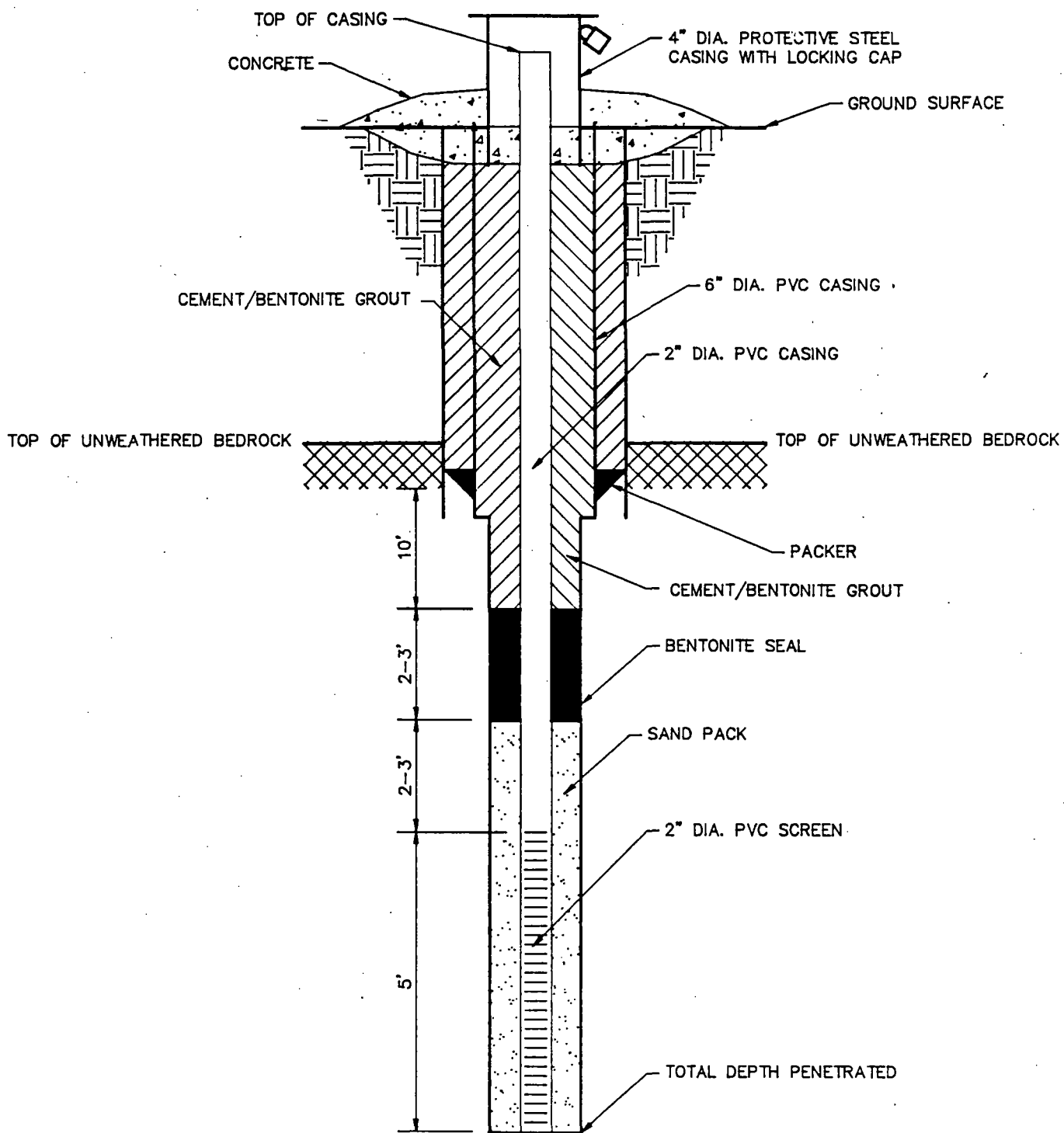
04011MGD  
VR042892

**FIGURE 5**  
**SCHEMATIC OF MONITORING**  
**WELL CONSTRUCTION IN**  
**GLACIAL DEPOSITS**

ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

MAY, 1992

04011.01



04011MBD  
VR042892

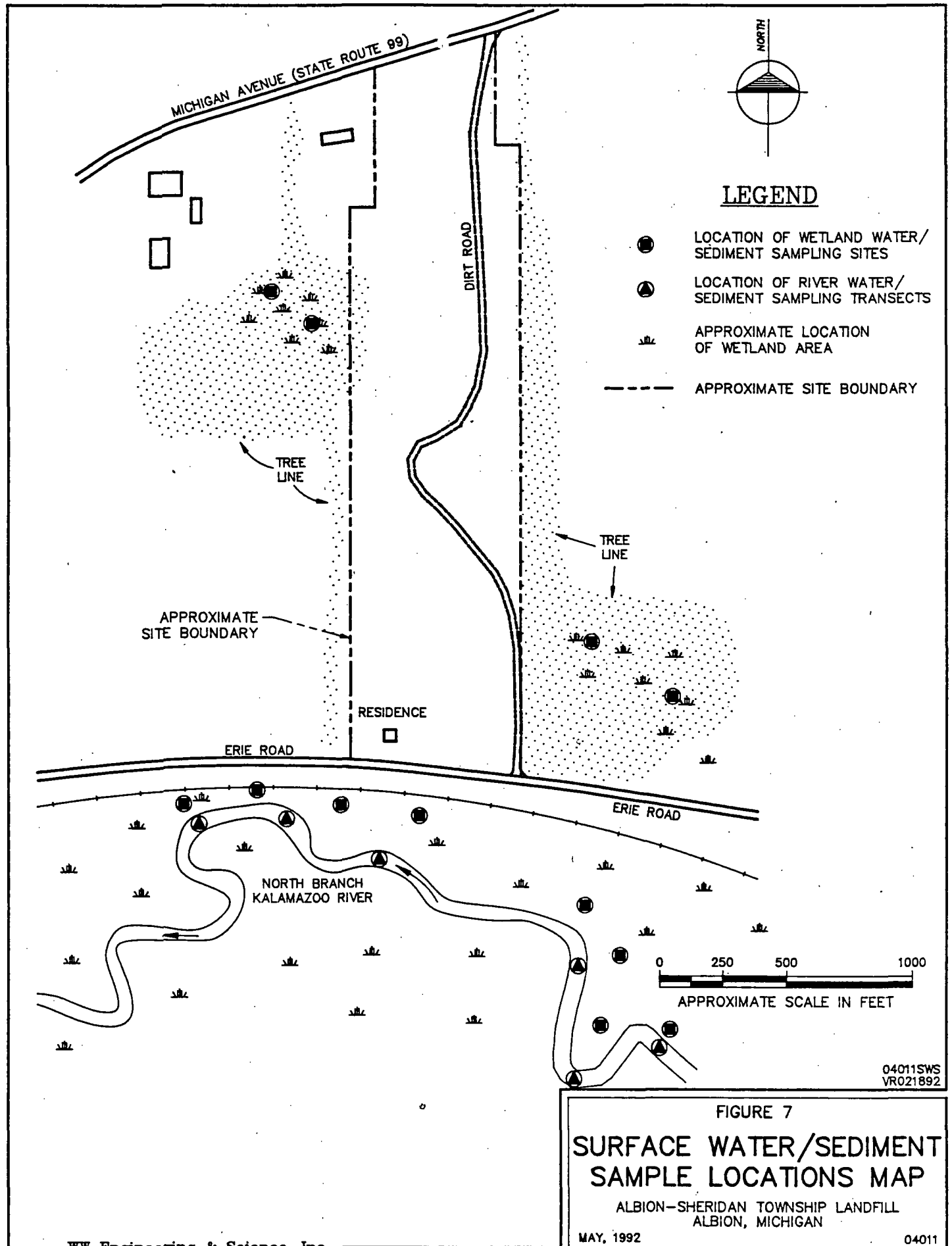
FIGURE 6  
**SCHEMATIC OF MONITORING  
WELL CONSTRUCTION IN  
BEDROCK**

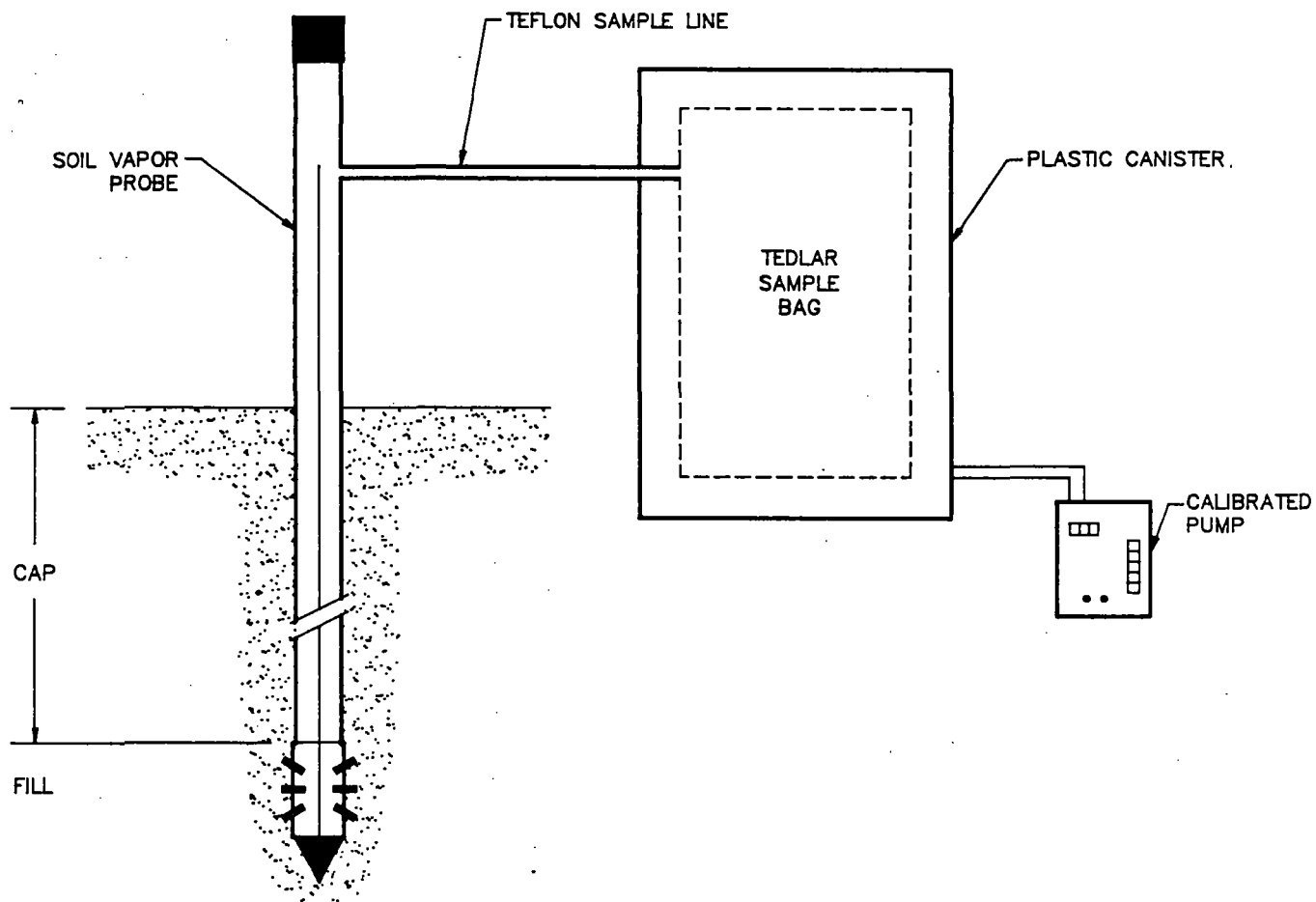
ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

MAY, 1992

04011.01







04011SSV  
VR022192

**FIGURE 8**  
**SCHEMATIC FOR SOIL  
VAPOR SAMPLING**

ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

MAY, 1992

04011.01



**TABLE 1**  
**SUMMARY OF WASTE SAMPLING AND ANALYSIS PROGRAM**  
**BORING SAMPLES**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	<u>NUMBER OF QUALITY ASSURANCE SAMPLES</u>					TOTAL MS/MSD SAMPLES
				DUPLICATES	FIELD BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	(4)	
Landfill Wastes (Medium Hazard)*	TCL organics package from CLP	IV	6	1	0	0	0	1	7
	TCL organics package from CLP VOA's only (Blank samples only)	IV	0	0	0	1	1	0 <sup>(5)</sup>	1
	TAL inorganics from CLP	IV	6	1	0	0	0	0 <sup>(5)</sup>	7
	SAS TCLP (Metals only)	V	6	1	0	0	0	1	7

(1) In addition to the laboratory parameters, the samples will be qualitatively field screened with a PID.

(2) DQO - Data Quality Objective.

(3) The number of blanks are estimated only. The number may vary depending on field conditions.

(4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.

(5) QA/QC for TAL inorganics includes MS/Sample duplicate

\* If the sample is oily or determined to be of mixed matrix, the samples will be retained until further arrangements can be made.

**TABLE 2**  
**SUMMARY OF LEACHATE WATER SAMPLING AND ANALYSIS PROGRAM**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					
				DUPLICATES	FIELD BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (4)	TOTAL SAMPLES
Leachate Water (Low or Medium Hazard)	TCL organics package from CLP (1st round)	IV	3	1	1	0	1	1	5
	TCL organics package from CLP VOA's only (Blank samples only, 1st round)	IV	0	0	0	1	1	0	1
	TAL inorganics from CLP (1st round)	IV	3	1	1	0	1	0 <sup>(5)</sup>	5
	SAS TOC (1 round only)	V	3	1	1	0	1	1	5
	SAS COD (1 round only)	V	3	1	1	0	1	1	5
	SAS BOD (1 round only)	V	3	1	1	0	1	0	5
	SAS TSS (1 round only)	V	3	1	1	0	1	0	5
	SAS TDS (1 round only)	V	3	1	1	0	1	0	5
	SAS Oil and Grease (total from both rounds)	V	6	2	2	0	2	0	10
	SAS Chloride (total from both rounds)	V	6	2	2	0	2	2	10
	SAS Sulfate (total from both rounds)	V	6	2	2	0	2	2	10
	SAS Nitrate (total from both rounds)	V	6	2	2	0	2	2	10
	SAS Ammonia (total from both rounds)	V	6	2	2	0	2	2	10
	SAS TKN Nitrogen (total from both rounds)	V	6	2	2	0	2	2	10

- (1) In addition to the laboratory parameters, pH, Eh, specific conductivity and temperature measurements will be taken in the field for each sample collected.
- (2) DQO - Data Quality Objective.
- (3) The number of blanks are estimated only. The number may vary depending on field conditions. The blank samples will be a deionized water matrix.
- (4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.
- (5) QA/QC for TAL inorganics includes MS/sample duplicate.

**TABLE 4**  
**SUMMARY OF SUBSURFACE SOIL SAMPLING AND ANALYSIS PROGRAM**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					TOTAL SAMPLES
				DUPLICATES	FIELD BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (4)	
Subsurface Soil (Low Hazard)	TCL organics package from CLP	IV	45	5	0	0	0	3	50
	TCL organics package from CLP VOA's only (Blank samples only)	IV	0	0	0	10	10	0	10
	TAL inorganics from CLP	IV	45	5	0	0	0	0 <sup>(6)</sup>	50
	SAS CEC	V	6	1	0	0	0	0	7
	Atterberg Limits (ASTM D4318) by WWES	III	20	2	0	0	0	0	22
	Particle Size Analysis (ASTM D422) by WWES	III	20	2	0	0	0	0	22
	Permeability (ASTM D 2434) by WWES <sup>(5)</sup>	III	20	0	0	0	0	0	20

(1) In addition to the laboratory parameters, the samples will be qualitatively field screened with a PID.

(2) DQO - Data Quality Objective.

(3) The number of blanks are estimated only. The number may vary depending on field conditions.

(4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.

(5) Duplicate samples for permeability measurements will not be collected because it would require drilling an additional borehole.

(6) QA/QC for TAL inorganics includes MS/sample duplicate.

**TABLE 5**  
**SUMMARY OF GROUND WATER MONITORING WELLS**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

<u>Location</u>	<u>Glacial Deposits</u>		<u>Bedrock</u>	
	<u>Shallow</u>	<u>Deep</u>	<u>Shallow</u>	<u>Deep</u>
MW-1	X	X	X	
MW-2	X	X	X	
MW-3	X	X	X	
MW-4	X	X	X	
MW-5	X	X	X	
MW-6	X	X	X	X
MW-7	X	X		
MW-8	X	X	O	
MW-9	X	X	O	
MW-10	X			
MW-11	X			
MW-12	X			
MW-13	X			
MW-14	O	O	O	
MW-15	O	O	O	

X = Proposed

O = Optional

Total number of proposed wells = 29

Total number of optional wells = 8

Maximum number of wells installed during Phase I = 37

**TABLE 6**  
**SUMMARY OF GROUND WATER SAMPLING AND ANALYSIS PROGRAM**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					
				DUPLICATES	FIELD BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (5)	TOTAL SAMPLES
Ground Water (Low Hazard)	TCL organics package from CLP (1st round)	IV	37	4	4	0	4	2	45
	SAS Low Level Organics Package or TCL from CLP (2nd round) <sup>(4)</sup>	V, IV	37	4	4	0	4	4 <sup>(7)</sup>	45
	TCL organics package from CLP VOA's only (Blank samples only, 1st round)	IV	0	0	0	10	10	0	10
	SAS Low Level Organics Package, or CLP for VOA's only (Blank Samples only, 2nd round) <sup>(4)</sup>	V, IV	0	0	0	10	10	0	10
	TAL inorganics from CLP (1st round)	IV	37	4	4	0	4	0 <sup>(6)</sup>	45
	SAS Low Level Inorganics or TAL from CLP <sup>(4)</sup> (2nd round)	V, IV	37	4	4	0	4	4	45
	SAS TOC (1 round only)	V	37	4	4	0	4	4	45
	SAS COD (1 round only)	V	37	4	4	0	4	4	45
	SAS BOD (1 round only)	V	37	4	4	0	4	0	45
	SAS TSS (1 round only)	V	37	4	4	0	4	0	45
	SAS TDS (1 round only)	V	37	4	4	0	4	0	45
	SAS Oil and Grease (1 round only)	V	37	4	4	0	4	0	45
	SAS Chloride (total from both rounds)	V	74	8	8	0	8	8	90
	SAS Sulfate (total from both rounds)	V	74	8	8	0	8	8	90
	SAS Nitrate (total from both rounds)	V	74	8	8	0	8	8	90
	SAS Ammonia (total from both rounds)	V	74	8	8	0	8	8	90
	SAS TKN Nitrogen (total from both rounds)	V	74	8	8	0	8	8	90

(1) In addition to the laboratory parameters, pH, Eh, specific conductivity and temperature measurements will be taken in the field for each sample collected.

(2) DQO - Data Quality Objective.

(3) The number of blanks are estimated only. The number may vary depending on field conditions. The blank samples will be a deionized water matrix.

(4) Based upon the results of the 1st round analyses, the 2nd round can be analyzed using either CLP or low level residential SAS.

(5) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.

(6) QA/QC for TAL inorganics includes MS/sample duplicate.

(7) Performance Evaluation Samples (PES) if SAS is used.



TABLE 7

**FIELD GC SAMPLING PARAMETERS  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

<u>Compound</u>	<u>Ground Water Detection Limit (ppb)</u>	<u>Soil Vapor Detection Limit (ppb)</u>
Benzene	1-10	300
Bromodichloromethane	1-10	300
Bromoform	1-10	300
Bromomethane	1-10	300
Carbon Tetrachloride	1-10	300
Chlorobenzene	1-10	300
Chloroethane	1-10	300
2-Chloroethylvinyl ether	1-10	300
Chloroform	1-10	300
Chloromethane	1-10	300
Dibromochloromethane	1-10	300
Dichlorodifluoromethane	1-10	300
1,1-Dichloroethane	1-10	300
1,2-Dichloroethane	1-10	300
1,1-Dichloroethylene	1-10	300
Total-1,2-Dichloroethylene	1-10	300
1,2-Dichloropropane	1-10	300
Cis-1,3-Dichloropropylene	1-10	300
Trans-1,3-Dichloropropylene	1-10	300
Ethyl benzene	1-10	300
Methylene chloride	1-10	300
1,1,2,2-tetrachloroethane	1-10	300
Tetrachloroethylene	1-10	300
Toluene	1-10	300
1,1,1-Trichloroethane	1-10	300
1,1,2-Trichloroethane	1-10	300
Trichloroethylene	1-10	300
Trichlorofluoromethane	1-10	300
Vinyl chloride	1-10	300

**TABLE 8**  
**SUMMARY OF SURFACE WATER SAMPLING AND ANALYSIS PROGRAM**  
**ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					TOTAL MS/MSD SAMPLES
				DUPLICATES	FIELD* BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (4)	
Surface Water (Low Hazard)	SAS Low Level Organics Package	V	24	3	0	0	0	3 <sup>(6)</sup>	27
	SAS Low Level Organics Package for VOA's only (Blank Samples only)	V	0	0	0	3	3	0	3
	SAS Low Level Metals (Filtered)	V	24	3	0	0	0	0 <sup>(5)</sup>	27
	SAS Low Level Metals (Unfiltered)	V	24	3	0	0	0	0 <sup>(5)</sup>	27
	SAS Low Level Cyanide (Unfiltered)	V	24	3	0	0	0	0 <sup>(5)</sup>	27
	SAS TDS	V	24	3	0	0	0	0	27
	SAS TSS	V	24	3	0	0	0	0	27
	SAS Chloride	V	24	3	0	0	0	3	27
	SAS Sulfate	V	24	3	0	0	0	3	27

- (1) In addition to the laboratory parameters, pH, Eh, specific conductivity and temperature measurements will be taken in the field for each sample collected.
- (2) DQO - Data Quality Objective.
- (3) The number of blanks are estimated only. The number may vary depending on field conditions. The blank samples will be a deionized water matrix.
- (4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.
- (5) QA/QC for inorganics includes MS/sample duplicate.
- (6) These are Performance Evaluation Samples.
- \* No equipment will be used to collect the samples, therefore, no equipment field blanks will be collected.

TABLE 9

**SUMMARY OF SEDIMENT SAMPLING AND ANALYSIS PROGRAM  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					TOTAL MS/MSD (4)	TOTAL SAMPLES
				DUPLICATES	FIELD* BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>			
Sediment (Low Hazard)	TCL organics package from CLP	IV	24	3	0	0	0	2	27	
	TCL organics package from CLP VOA's only (Blank samples only)	IV	0	0	0	3	3	0	3	
	TAL inorganics from CLP	IV	24	3	0	0	0	0 <sup>(5)</sup>	27	
	SAS TOC	V	24	3	0	0	0	0	27	

(1) In addition to the laboratory parameters, the samples will be qualitatively field screened with a PID.

(2) DQO - Data Quality Objective.

(3) The number of blanks are estimated only. The number may vary depending on field conditions.

(4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.

(5) QA/QC for TAL Inorganics includes MS/sample duplicate.

\* No equipment field blanks will be collected.

TABLE 10

**SUMMARY OF RESIDENTIAL WELL WATER SAMPLING AND ANALYSIS PROGRAM  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	NUMBER OF QUALITY ASSURANCE SAMPLES					TOTAL MS/MSD TOTAL SAMPLES
				DUPLICATES	FIELD* BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (4)	
Residential Wells (Low Hazard)	SAS Low Level Organics Package	V	20	2	0	0	0	2 <sup>(6)</sup>	22
	SAS Low Level Organics Package for VOA's only (Blank Samples only)	V	0	0	0	5	5	0	5
	SAS Low Level Inorganics	V	20	2	0	0	0	0 <sup>(5)</sup>	22
	SAS Chloride	V	20	2	0	0	0	2	22
	SAS Sulfate	V	20	2	0	0	0	2	22
	SAS Nitrate	V	20	2	0	0	0	2	22
	SAS Ammonia	V	20	2	0	0	0	2	22

- (1) In addition to the laboratory parameters, pH, Eh, specific conductivity and temperature measurements will be taken in the field for each sample collected.
- (2) DQO - Data Quality Objective.
- (3) The number of blanks are estimated only. The number may vary depending on field conditions. The blank samples will be a deionized water matrix.
- (4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.
- (5) QA/QC for inorganics includes MS/sample duplicate.
- (6) Performance Evaluation Samples (PES)
- \* No equipment will be used to collect the samples, therefore, no equipment field blank will be collected.

**TABLE 11**

**SUMMARY OF SURFACE SOIL SAMPLING AND ANALYSIS PROGRAM  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

SAMPLE MATRIX	LABORATORY PARAMETERS <sup>(1)</sup>	DQO <sup>(2)</sup> ANALYTICAL LEVEL	NUMBER OF INVESTIGATIVE SAMPLES	<u>NUMBER OF QUALITY ASSURANCE SAMPLES</u>					TOTAL MS/MSD TOTAL SAMPLES
				DUPLICATES	FIELD* BLANKS	TRIP BLANKS	TOTAL BLANKS <sup>(3)</sup>	MS/MSD (4)	
Surface Soil (Low Hazard)	TCL organics package from CLP	IV	16	2	0	0	0	1	18
	TCL organics package from CLP VOA's only (Blank samples only)	IV	0	0	0	2	2	0	2
	TAL inorganics from CLP	IV	16	2	0	0	0	0 <sup>(5)</sup>	18
	SAS TOC	V	16	2	0	0	0	0	18
	Particle Size Analysis (ASTM D422) by WWES	II	16	2	0	0	0	0	18

(1) In addition to the laboratory parameters, the samples will be qualitatively field screened with a PID.

(2) DQO - Data Quality Objective.

(3) The number of blanks are estimated only. The number may vary depending on field conditions.

(4) MS/MSD - Matrix spike/matrix spike duplicate. MS/MSD samples are not counted into the total number of samples. One MS/MSD sample will be collected for every 20 or less samples.

(5) QA/QC for TAL inorganics includes MS/sample duplicate.

\* No equipment field blanks will be collected.





## ***Appendix A***

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### ***Standard Operating Procedures***



## **ELECTROMAGNETIC SURVEYS**

Two instruments are commonly used for electromagnetic surveying; the Geonics EM31-D and the Geonics EM34-3.

### **GEONICS EM-31D GROUND CONDUCTIVITY METER**

#### **INSTRUMENT DESCRIPTION**

The EM31-D is a one-person portable unit, consisting of a transmitter and receiver coil and accompanying electronics housed in a single unit. The coil separation on the instrument is fixed at 3.66 meters. This yields a maximum exploration depth of around 5.5 meters (18 feet). The instrument is capable of measuring both in-phase and quadrature-phase data simultaneously. This allows survey data to be collected for delineation of buried metallic objects as well as characterization of terrain conductivity.

The instrument may be operated in either a horizontal or vertical coplanar dipole mode. The instrument is normally operated in the vertical dipole mode. The depth of investigation is approximately 5.5 meters (18 feet) in this mode. In the horizontal dipole mode, the instrument is rotated 90 degrees about a horizontal axis. The depth of investigation is approximately 3 meters (9 feet) in this mode. Data are recorded and stored continuously or in discrete samples using the Omnidata Polycorder data logging system described below or a simple two channel analog strip chart recorder. Quadrature-phase terrain conductivity measurements are recorded in millimhos per meter (mmho/m), while in-phase measurements are recorded in parts per thousand (ppt) of the primary field.

#### **OMNIDATA POLYCORDER DATA LOGGING SYSTEM**

The Omnidata Polycorder data logging system is used to digitally record and store electromagnetic data acquired with the EM31-D instrument. The Omnidata system is comprised of a polycorder digital data recorder, a program contained in two polycorder download modules, and associated cable to connect the polycorder to the Geonics EM31-D Ground Conductivity Meter. The polycorder program is used to record survey data from the EM31-D under the control of the operator. Data can be collected in either the discrete station mode where the operator triggers data collection at every station or in the automatic mode where measurements are recorded at time intervals of 1-second while the instrument is being carried along a traverse line. In the automatic mode, data collection can be effectively continuous if a moderate survey speed (about 2 mph) is maintained. Station marks are entered by the operator during each traverse as a station is passed. In addition, the polycorder stores field information such as survey line number, station number, and comments.

#### **SETUP PROCEDURE AND CALIBRATION**

## **GEONICS EM 31-D GROUND CONDUCTIVITY METER**

### **Instrument Setup**

- Instrument setup should be done in an area free of cultural interference and man-made conductors such as buried pipes, buildings, power lines and steel reinforced concrete, etc.
- Check battery condition and replace, if necessary.
- Attach transmitter coil boom to instrument.
- Set instrument to OPER mode, adjust range to least sensitive (1,000 mmhos/m) setting, check zero reading, and adjust DC ZERO CONTROL, if necessary.
- Turn instrument OFF. Connect receiver coil to instrument.
- Turn instrument on and begin functional checks.

### **Equipment Functional Checks**

- Set range to 30 mmhos/m.
- Set mode to COMP. Adjust meter reading to zero, using compensation controls.
- Set mode to PHASE. Note meter reading. Rotate COARSE compensation control 1 step clockwise. Note meter reading. If meter reading is constant, no phase adjustment is necessary. Return COARSE control to original position. If meter reading is not constant, see manual for phase adjustment.
- Set mode to COMP. Rotate COARSE control clockwise one step. Note meter reading. If reading is between 22 and 26 mmhos/m, instrument sensitivity does not require adjustment. Record the meter reading. If the reading is not between 22 and 26 mmhos/m, sensitivity needs adjustment. See the manufacturer's recommendations.
- After appropriate adjustments, begin the survey.

## **INSTRUMENT CALIBRATION**

### **ABSOLUTE CALIBRATION**

An area for calibration is chosen at the site. The instrument calibration is cross referenced to this location at the beginning and end of each field day, or when deemed necessary after breaks in field surveying. Readings observed during cross referencing are recorded for possible future use.

## FIELD PROCEDURES

EM data can be collected at discrete station locations or continuously along traverse lines which have been defined by a survey grid (see documentation on field gridding). The survey area, station and traverse line spacing and traverse line orientation are selected to optimize the quality of results obtained from the EM survey.

Each traverse specified by the survey grid has a corresponding traverse line number. The traverse lines are usually separated by a specific distance or grid interval. Along each traverse line are station locations where data will be collected. Each station location is also separated by specific distance along the traverse line. Data collection in this manner allows each data point to be identified by two coordinate values. The coordinates for any data point represent the traverse line number and the station location on the traverse. Station locations along traverses always increase in the same direction and at specified intervals among traverse lines (see documentation of field gridding).

Both the quadrature-phase and in-phase components are usually recorded while using the EM31-D. A single operator carries the instrument while traversing (walking) along lines laid out by the survey grid. The data can be collected continuously or at specified intervals (station locations). At the start of each traverse line, the operator inputs the traverse line number, traverse direction, starting station location, and station increment into the data recorder. Where station measurements are to be made, the operator then occupies a station location, brings the instrument to an approximate level position and activates a switch on the instrument to record the EM data at that location. The Omnidata Polycorder automatically records the data along with the appropriate station coordinates. The Omnidata recorder automatically increments the station coordinates after each recording and is ready to record at the next station location. Data collection in this manner is relatively quick. Data can be collected at almost a walking pace with additional time required only to input traverse line information at the beginning of each new traverse. Where measurements are to be made continuously along a traverse line, the operator activates the continuous data collection mode on the polycorder to begin data collection at 1 second intervals and then walks the traverse line, triggering the station mark switch as each station is passed. EM data can also be collected and recorded continuously using a two channel analog strip chart recorder.

After field surveying, the data is transferred to a personal computer at the site, if possible. Data reduction or processing is performed to allow the operator to view the data in a suitable format. If the data has been recorded using an analog strip chart recorder, it can be reviewed immediately in the field. The data is then checked for quality control. Field reduction and review of the data also allows the operator to determine if additional surveying may be necessary to better define anomalous areas at the site before leaving the site.

## DECONTAMINATION

Electromagnetic surveying is non-obtrusive. No part of the instrument contacts the ground surface. Decontamination of the equipment is usually unnecessary.

## **DOCUMENTATION**

Documentation of field surveying is usually in the form of one or more contour maps or profile plots depicting the character of the electromagnetic field at the site. A map depicting the survey grid coordinates, data locations and data values may accompany the contoured data and/or the profile plots.

## **GEONICS EM34-3 GROUND CONDUCTIVITY METER**

### **INSTRUMENT DESCRIPTION**

The EM34-3 is a two-person portable unit, consisting of a transmitter and receiver coil and accompanying electronics housed in a receiver console and a transmitter console. The coil separation on the instrument is adjustable to 10, 20, and 40 meters. With coils oriented vertically, these spacings yield maximum exploration depths of around 15, 30, and 60 meters, respectively. The instrument is capable of measuring both quadrature-phase and in some instances, in-phase data. This allows survey data to be collected for delineation of buried metallic objects as well as characterization of terrain conductivity.

At each coil spacing, the instrument may be operated in either a horizontal or vertical coplanar dipole mode. In the horizontal dipole mode, the instrument is rotated 90 degrees about a horizontal axis. The depth of investigation in this mode is less than that obtained using the vertical dipole orientation. Data can be recorded at station intervals and stored in discrete samples using the Omnidata Polycorder data logging system described below or collected and recorded continuously using two person boom with coils fixed at ten meters separation and a simple two channel analog strip chart recorder. Quadrature-phase terrain conductivity measurements are recorded in millimhos per meter (mmho/m), while in-phase measurements are recorded in parts per thousand (ppt) of the primary field.

### **OMNIDATA POLYCORDER DATA LOGGING SYSTEM**

The Omnidata Polycorder data logging system is used to digitally record and store electromagnetic data acquired with the EM34-3 instrument. The Omnidata system is comprised of a polycorder digital data recorder, a program contained in two polycorder download modules, and associated cable to connect the polycorder to the Geonics EM34-3 Ground Conductivity Meter. The polycorder program is used to record survey data from the EM34-3 under the control of the operator. Data can be collected in the discrete station mode only where the operator triggers data collection at every station. In addition, the polycorder stores field information such as survey line number, station

number, and comments. In addition, the polycorder stores field information such as survey line number, station number, and comments.

EM data can be collected in the continuous mode using the 10-meter coil spacing and recorded using an analog strip chart recorder. Station marks are entered by the operator along each traverse, as a station is passed.

## **SETUP PROCEDURE AND CALIBRATION**

### **GEONICS EM 34-3 GROUND CONDUCTIVITY METER**

#### **Instrument Setup**

- Instrument setup should be done in an area free of cultural interference and man-made conductors such as buried pipes, buildings, power lines and steel reinforced concrete, etc.
- Position the coils on the ground 10 meters apart with the red circles on the coils facing the same direction. Connect the reference cable - one end to the 8-pin connector on the transmitter (Tx) coil and the other end to the "REFERENCE" connector on the receiver console.
- Connect the Tx coil to the Tx console using the appropriate short cable.
- Set the "LEVEL" switch on the transmitter console to the "NORMAL" position.
- Set the transmitter console "SEPARATION" switch to the 10-meter position and turn on the transmitter.
- Check to see that the battery monitor meter indicator on the transmitter console is in the black area of the scale. If not, batteries are low or are not making proper contact with the battery clips.
- Check the condition of the receiver (Rx) batteries by setting the receiver console "SEPARATION" switch to the "BATT" position with "POWER/OFF" switch to the "OFF" position.
- Set the receiver console "SEPARATION" switch to 10 meters.

#### **Electronic Nulling - to remove any offsets in the output (DC) circuitry.**

- Prior to turning the instrument on, insure that meters read zero by adjusting the mechanical meter zero control.

- Turn on the receiver console.
- With the Rx coil disconnected, depress the "NULL MODE" push button switch. Both meter needles should go to zero.
- If either needle does not go to zero, release the lock on the appropriate "NULL" control potentiometer. With the "NULL MODE" switch depressed, adjust the "NULL" control to zero the meter.
- Lock the "NULL" control.
- Connect the Rx coil to the receiver console "COIL" connector via the appropriate short cable.

### **Receiver Compensation and Gain Check**

- While maintaining the Tx and Rx coils in the same plane, adjust the coil separation to obtain a zero reading on the "COIL SEPARATION" meter (be sure that the red circles on the coils face the same direction). The coil separation should now measure 10 meters with some slack in the connecting cable.
- With the "SENSITIVITY RANGE" set to the 300 mmhos/m position, move the Rx coil toward the Tx coil until the "COIL SEPARATION" meter deflects to full scale.
- Measure the distance the coil has moved. This distance should be 10.4 % of the intercoil spacing (1.4 meters or 3.41 feet).

### **Taking a Reading**

- The "SEPARATION" setting on both the Tx and Rx consoles should be set to the appropriate setting (10, 20 or 40 meters).
- At each station, the transmitter operator positions himself and remains stationary. The receiver operator should position the Rx coil such that the "COIL SEPARATION" meter reads in the green area.
- The "SENSITIVITY RANGE" should be set such that the "CONDUCTIVITY" reading is in the upper 70% of the scale. The meter reading should then be recorded in mmhos/m.

NOTE: In particularly sensitive settings, the Rx and Tx consoles should be separated from their respective coils by 0.7 and 1.0 meter.

### **Daily Periodic Checks**

- To keep drift under control, the electronic nulling procedure should be repeated at least once per each day of survey.
- Receiver Batteries: The Rx battery check is done by switching the "SEPARATION" switch to the "BATT" position and the power switch to "OFF". The meter will then indicate the condition of the two sets of receiver batteries. If low, replace the batteries or see that the contacts are clean.
- Transmitter Batteries: With the Tx coil connected and the "LEVEL" switch in the "HIGH" position, the battery monitor meter should read in the black area of the scale.

### **Transmitter Output Power**

- The Tx output power should be kept in the "NORMAL" position for increased battery life. Under noisy conditions (power lines or spherics) the transmitter power should be increased to the "HIGH" position.

## **INSTRUMENT CALIBRATION**

### **ABSOLUTE CALIBRATION**

An area for calibration is chosen at the site. The instrument calibration is cross referenced to this location at the beginning and end of each field day, or when deemed necessary after breaks in field surveying. Readings observed during cross referencing are recorded for possible future use.

### **FIELD PROCEDURES**

EM data can be collected at discrete station locations or continuously along traverse lines which have been defined by a survey grid (see documentation on field gridding). The survey area, station and traverse line spacing and traverse line orientation are selected to optimize the quality of results obtained from the EM survey.

Each traverse specified by the survey grid has a corresponding traverse line number. The traverse lines are usually separated by a specific distance or grid interval. Along each traverse line are station locations where data will be collected. Each station location is also separated by specific distance along the traverse line. Data collection in this manner allows each data point to be identified by two coordinate values. The coordinates for any data point represent the traverse line number and the station location on the traverse. Station locations along traverses always increase in the same direction and at specified intervals among traverse lines (see documentation of field gridding).

The quadrature-phase component is usually recorded while using the EM34-3. Two operators are required to make station measurements. Data can be recorded in a field

notebook or using the Omnidata Polycorder. At each station, measurements can be made using coil configurations ranging from one separation and orientation up to a complete sounding (10, 20 and 40 meter separations with horizontal and vertical dipole orientations). To make a measurement, the coils should be positioned at the desired separation(s) and orientation(s) and the conductivity measurements should be collected as described above. If a polycorder is used, the operator inputs the traverse line number, traverse direction, starting station location, and station increment into the data recorder at the beginning of each traverse line. When the operator activates a switch on the instrument to record the EM data at each station location, the Omnidata Polycorder automatically records the data along with the appropriate station coordinates. The Omnidata recorder automatically increments the station coordinates after each recording and is ready to record at the next station location.

Measurements can be made continuously along a traverse line, using a two person boom to transport the coils at a fixed 10 meter spacing, only. The Rx console is connected to an analog strip chart recorder while the survey crew walks the traverse line. It is recommended that an additional crew member be used to carry the recorder and activate the station mark switch as each station is passed.

After field surveying, the data is transferred to a personal computer at the site, if possible. Data reduction or processing is performed to allow the operator to view the data in a suitable format. If the data has been recorded using an analog strip chart recorder, it can be reviewed immediately in the field. The data is then checked for quality control. Field reduction and review of the data also allows the operator to determine if additional surveying may be necessary to better define anomalous areas at the site before leaving the site.

## **DECONTAMINATION**

Electromagnetic surveying is non-obtrusive. No part of the instrument contacts the ground surface. Decontamination of the equipment is usually unnecessary.

## **DOCUMENTATION**

Documentation of field surveying is usually in the form of one or more contour maps or profile plots depicting the character of the electromagnetic field at the site. A map depicting the survey grid coordinates, data locations and data values may accompany the contoured data and/or the profile plots.

## **REFERENCES**

Operating Manual for EM31-D Non-Contacting Terrain Conductivity Meter (June, 1984, Rev.), Geonics Limited (pp. 60 + ii, 2 appendices).



Operating Manual for EM34-3 Non-Contacting Terrain Conductivity Meter (July, 1985,  
Rev.), Geonics Limited.

## **RESISTIVITY SURVEYS**

### **INSTRUMENT DESCRIPTION**

A number of instruments are used for resistivity surveying. The two instruments typically used by WW Engineering & Science are the ABEM Terrameter and the BISON Model 2350 Earth Resistivity Meter. Both instruments can be used independently or in conjunction with the Bison Offset Sounding System "BOSS", when conducting electrical resistivity soundings.

#### **Abem Terrameter and Bison Model 2350 Resistivity Meter**

The Abem and Bison resistivity meters are self-contained units with built-in batteries and milliampere meters for continuous monitoring of electrode current. Housed within a single casing are a transmitter, a receiver and in the case of the ABEM a microprocessor. The transmitter sends out a current of specified duration and strength. The receiver discriminates between noise and the generated signal and measures the voltages associated with the signal current. The microprocessor monitors and controls operations and performs calculations.

Accessory equipment consists of heavy duty reels with up to 400 meters of insulated cable, 2 current electrodes, and 2 to 3 potential electrodes. Current electrodes should be made of stainless steel whereas potential electrodes can be made of either stainless steel or hollow plastic tubing with porous tips. If porous tipped potential electrodes are used they should be kept filled with a copper sulfate solution. Both instruments can be connected to a variety of commonly used electrode arrangements including the Wenner, Schlumberger, Pole-dipole, Dipole-dipole and Lee arrays.

Alternatively, the instruments may be used with the Bison Offset Sounding System, (BOSS), which is comprised of a central switch or control box and two nylon-covered, multi-conductor cables with standard takeouts at each electrode position (a total of 19 electrodes). The BOSS System configuration allows Wenner apparent resistivity readings to be obtained by rotating switches on the central control box rather than by physically changing electrode positions during the survey. A further advantage of the BOSS System is the ability to change the center of the array by an offset of one or two electrode distances in either direction, thereby cancelling out the effects of lateral changes in resistivity, potentially present if only one measurement were taken.

## **THE CONCEPT OF ELECTRICAL RESISTIVITY SURVEYING**

Electrical resistivity is the method by which the apparent resistivity of the subsurface is determined from the application of electrical current into the earth from current electrodes, and the measurement of the resulting voltage across potential electrodes. Apparent resistivity  $r(a)$ , is defined as an Ohm's Law ratio of measured voltage  $V$ , to applied current  $I$ , with the added effect of a geometrical constant  $K$ , which is dependent on the configuration of the electrode array ( $r(a) = KV/I$ ). The apparent resistivity would equal the true resistivity of the subsurface if the subsurface were homogeneous and isotropic. For a heterogeneous subsurface, the apparent resistivity may be lower or higher than the true resistivity.

The flow of the applied electrical current through subsurface materials is primarily electrolytic and is dependent on the presence of pore fluid water (ground water), and the amount of electrolytes that it contains. Where ground water is absent, electrical flow is controlled to a large degree by clay particles, with the requirement that these particles be surrounded by a layer of moisture at least a few molecules thick. Current flux lines will be concentrated in these more conductive zones with the resulting effect of lower resistivities than for unsaturated or partially saturated zones.

## **SETUP PROCEDURE**

The setup procedure for resistivity surveying is relatively simple. No calibration of the instrument is required. The instrument setup consists of the following steps:

- Check battery condition and replace if necessary.
- Stretch shielded electrode cables out in a straight line, to the required distance.
- Drive electrodes into the ground at the appropriate intervals. If dry, highly resistive soil is encountered the electrodes may have to be driven into the ground at least 1-foot and or be watered.
- Connect shielded current and potential cables to the proper terminals on the resistivity instrument.
- Connect electrodes to the shielded cables.
- After making appropriate adjustments to current strength and ensuring that good electrical contact exists between the ground and the electrodes, begin the survey.

## **FIELD PROCEDURES**

In resistivity surveying any accepted configuration can be used with the techniques of horizontal and vertical profiling. In horizontal profiling the electrode separation is kept constant and the entire array is moved along a traverse with measurements taken at

regular intervals, usually at every electrode position or "a", spacing. By this method the depth of current penetration is fixed and lateral variations in subsurface geology are investigated.

In vertical profiling, also called Vertical Electrical Sounding (VES), the center of the array remains fixed and measurements are obtained for successively larger electrode separations. Because a greater portion of the current flux lines penetrate deeper when the electrodes are further apart, the data give more information about the deeper subsurface geology. For VES either the Schlumberger array or the BOSS System with offset capability are preferred.

After the voltage  $V$  has been measured the instrument will display  $V$  or the value  $V/I$ , depending on its sophistication. Once  $V/I$  has been obtained it must be multiplied by the geometrical factor  $K$ , to obtain the apparent resistivity. These calculations should be performed in the field immediately after each measurement.

### **DECONTAMINATION**

Resistivity surveying is relatively non-obtrusive, and requires minimal decontamination. Care must be taken during decontamination to ensure that the electronic circuitry be kept dry. The cables and bottom of the instrument case can be wiped down with a damp cloth. Electrodes can be washed with soap and water followed by a clean water rinse.

### **DOCUMENTATION**

Documentation of resistivity surveying is usually in the form of resistivity contour maps or geoelectric cross-sections. A site map showing the locations of vertical electrical soundings and/or profile lines should accompany the interpreted data.

### **REFERENCES**

Mooney, H. M., (1980) Handbook of Engineering Geophysics (Vol. 2). Minneapolis, MN: Bison Instruments.

Grant, F. S., & West, A. F. (1965). Interpretation Theory in Applied Geophysics. New York: McGraw-Hill.

## **SPLIT-SPOON SAMPLING**

Soil borings that are drilled for a geotechnical study (i.e., a study designed to determine the compressive strength of the soil for the purpose of new building construction) are usually sampled at 2.5-foot intervals in the first 10 feet below grade and at 5-foot intervals thereafter to the bottom of the boring.

The depths from which soil samples are collected in an environmental investigation can be very site-specific. Soil samples are often collected from depths most likely to show environmental impact based on an evaluation of the known or suspected contaminants, the characteristics of the soils, and other variables that may affect a particular site.

Collecting a soil sample with a split-spoon or split-barrel sampling device is a common technique used to determine the physical soil characteristics and soil quality. It is described by ASTM Method D-1586 and is summarized below.

### **JOB DESCRIPTION:**

Obtain soil samples at specified intervals, and collect the soil for laboratory analyses.

### **TASK-SPECIFIC EQUIPMENT NEEDED:**

- drilling and sampling devices
- tape for locating
- well/boring log sheets

### **EXPECTATIONS:**

A well/boring log sheet will be accurately completed at each well or boring, according to WWES's standard operating procedure "Well/Boring Log Guidelines", including blow counts, PID or FID response, soil descriptions, and other soil boring details.

The boring will be located by measurements and labeled on a site sketch or base map.

### **PROCEDURE:**

1. Advance the boring to the desired sampling depth.
2. Attach the split-spoon sampling device to the bottom end of the drilling rods and gently lower it to the bottom of the borehole.

3. A 140-pound hammer free-falling a distance of 30 inches is used to drive the 2-inch O.D. split spoon 18 inches into the undisturbed soil below. Drive the 2-inch O.D. split-spoon sampler into the undisturbed soil ahead of the lead auger.
4. Record the number of blows required to drive the sampler for each 6-inch increment. If the soil is particularly hard and the blow counts are in excess of 100 blows per 6 inches, a split spoon may not be capable of obtaining the sample. Stop to keep from damaging the sampling device.
5. Bring the split spoon back to the ground surface after it has been driven over the sample interval.
6. Open the split spoon.
7. Field screen the sample if it is required.
8. Take samples that are collected for lab analyses from the mid to lower portions of the split spoon. Immediately place the soil that is most likely to be impacted (based on PID or FID response and visual observations of staining) into the appropriate sample bottles. Collect the samples to be analyzed for volatile organic compounds first. Collect the soil for semi-volatile analyses next, and collect soil for inorganic analyses last.
9. Place the samples in appropriate containers, using a clean tool and/or clean gloves.
10. Visually inspect the sample and describe it accurately and completely on the well/boring log sheet.

The upper portion of soil in the sampler can be disturbed or not representative of the sample interval targeted. This is because residual soils from within the auger stem may become entrained in the sample. The upper portion should be observed but field judgment should be used as to whether it is really representative of the sample interval. The upper portion should not be collected for lab analyses.

## **MAGNETOMETER SURVEYS**

### **INSTRUMENT DESCRIPTION**

The instrument used by WW Engineering & Science for magnetic surveying is the EDA OMNI IV proton precession magnetometer/gradiometer. EDA is now owned by Sintrex.

The EDA OMNI IV is a one-man portable unit, consisting of a sensor head mounted on a variable height staff, with accompanying electronics mounted in a separate unit. The sensor head contains two sealed bottles filled with a proton rich liquid, each surrounded by a coil. The instrument is capable of simultaneously recording both total magnetic field and magnetic gradient. Total magnetic field readings are obtained from the upper sensor bottle, while the magnetic gradient is derived from the difference between the upper and lower sensor readings. Total magnetic field values are in units of gammas, while magnetic gradient values are in units of gammas/meter.

The instrument has built-in quality control functions which alert the operator when data of inappropriate accuracy are being obtained. Total field readings having an estimated error of greater than  $\pm 2.3$  gammas cannot be recorded by the operator. In this instance, a new reading must be taken until an error of less than  $\pm 2.3$  gammas has been obtained ( $\pm 2.3$  gammas represents an accuracy of approximately 0.004% of the average total field value). Estimated error values, drift, time, date, profile line and position coordinates, total magnetic field, and magnetic gradient are recorded and stored for each data point.

### **SETUP PROCEDURE AND CALIBRATION**

#### **Instrument Setup**

- Attach appropriate number of staff lengths to sensor head for desired sensor height.
- Attach sensor cable to instrument.
- Set instrument to TEST mode.
- Hold sensor head vertically and orient toward north.
- Press READ to take test reading, instrument should read 56369.7 GAMMA.
- Check battery condition, charge if necessary.
- Press ERROR to examine error, reading should be 00.0 GRAD.
- If TEST functions read incorrectly, see manual for adjustment.
- Begin survey.

## **INITIALIZATION/CALIBRATION**

The magnetometer must be initialized each calendar day or after transfer of data from the instrument. Initialization procedures for different operation modes are contained in the operations manual. Calibration of the magnetometer involves tuning the instrument to a total field value which is near the average ambient total magnetic field value for the investigation area. This allows the instrument to record total field values within approximately 15% variation (plus or minus) of the ambient total field with a high degree of accuracy. If the accuracy of a reading is degraded, the instrument will alert the operator to take another reading or tune the instrument to an appropriate total field value. Inaccurate readings are usually a result of extremely high magnetic gradients and/or total field values. The ambient total field strength in Michigan is approximately 57,000 gammas. If readings in areas free of induced magnetic fields differ significantly from this value, the magnetometer must be tuned by the operator to the appropriate value. This procedure is explained in the operating manual.

## **FIELD PROCEDURES**

The instrument must be initialized prior to beginning a survey. Magnetic measurements are typically acquired in the gradient mode. Both the total field strength and vertical magnetic gradient are recorded in this mode.

To obtain a magnetic reading at a location, the operator must first place the sensor staff in a vertical position with the sensor head oriented north. The READ button is pressed to power-up the instrument for obtaining a reading. The sensor head must be kept stationary for three seconds for a valid reading. Readings are stored into memory using a keyboard command given by the operator. When taking readings along predetermined profile lines, the profile line coordinate, starting position coordinate (station number), and station increment must be programmed into the magnetometer. The procedures for programming information into the magnetometer are explained in detail in the operations manual. Station locations along each profile line are then updated automatically as readings are obtained and stored into memory.

## **DATA TRANSFER**

The OMNI IV contains an internal clock which prevents readings from being acquired after 12:00 A.M. on any given day without first initializing the instrument. This is to prevent the previous day's data from being written over. All currently stored data must be transferred to a computer before initialization of the instrument may be performed. Transferring of data from the instrument to a personal computer is accomplished using the software package PROCOMM.



## **DECONTAMINATION**

The magnetometer contains very sensitive electronic circuitry. During decontamination, immersion of the magnetometer in water or cleaning it with steam must be avoided. The bottom of the sensor staff is the only part of the instrument which contacts the land surface. Therefore, rigorous cleaning of the instrument itself is usually not necessary. A soap and water rinse of the sensor staff should be sufficient.

## **DOCUMENTATION**

Documentation of field surveying is usually in the form of one or more contour maps depicting the character of the total magnetic field and magnetic gradient at the site. A map depicting the survey grid coordinates, data locations and data values may accompany the contoured data.

## **MAGNETIC THEORY**

### **ANOMALIES IN THE EARTH'S MAGNETIC FIELD**

Magnetic surveys are a common, very effective method for locating buried ferromagnetic materials such as buried tanks or metal debris. Any magnetically susceptible material placed in an external magnetic field will have magnetic poles induced upon its surface. These magnetic poles will produce a magnetic field of their own. Therefore, ferromagnetic objects which are present in the earth's magnetic field will produce a separate induced magnetic field.

### **ANOMALIES DUE TO BURIED MATERIALS**

Any induced magnetic field associated with a buried object or object near the surface is superimposed on the earth's field to yield a resultant total magnetic field which can be measured at the surface. The earth's magnetic field is generally characterized by smooth contours and low magnetic relief. Irregularities in the measured total magnetic field are a result of anomalous induced magnetic fields which may be caused by buried ferromagnetic materials.

### **PROTON PRECESSION MAGNETOMETER**

The Proton Precession Magnetometer is commonly used for magnetic surveying. The instrument utilizes a sensing device containing a liquid rich in hydrogen atoms (protons) surrounded by a coil. The protons act as small dipoles normally oriented parallel with the earth's magnetic field. A current is passed through the coil surrounding the proton rich liquid, generating a magnetic field much greater than the earth's ambient magnetic field. This causes the protons in the liquid to realign with their magnetic axes parallel to the induced magnetic field. The current in the coil is quickly switched off, eliminating the induced magnetic field. The protons then begin to realign their axes parallel to the earth's

total field. The forces present due to the spin of each proton cause them to precess around the earth's field for a period of 1-3 seconds before reaching their original orientation.

#### **TOTAL MAGNETIC FIELD VS PRECESSION**

The precession of protons following elimination of the induced magnetic field has a frequency associated with it. The frequency of the protons' precession is directly related to the strength of the total magnetic field. This frequency is monitored by measuring the alternating voltage induced in a coil due to the precession of protons. The frequency of precession is used to calculate the strength (in gammas) of the total magnetic field.

#### **MAGNETIC GRADIENT VS DEPTH OF BURIAL**

The magnetic field gradient, as well as the total magnetic field strength, is useful for interpretation of magnetic anomalies. Many magnetometers are capable of recording magnetic gradients concurrently with total magnetic field strength. A vertical magnetic gradient is the difference between the total magnetic field values measured at two vertically separated points. Deeply buried objects produce magnetic anomalies which generally have low magnetic gradients. Shallow objects usually produce high magnetic gradients.

#### **CONCURRENT TOTAL FIELD AND GRADIENT DATA**

Large objects or objects with a high magnetic susceptibility usually produce large total magnetic field anomalies. The total magnetic field and magnetic gradient data can be used concurrently to make a qualitative interpretation of magnetic anomalies. The size and magnetic susceptibility of objects can be estimated from the total magnetic field data while the relative depth of objects can be inferred from the magnetic gradient data.

#### **DIFFICULTY OF QUANTITATIVE INTERPRETATION**

Several factors influence the response of the magnetometer. These include the mass and depth as well as any permanent magnetism of a magnetically susceptible material. The response of the magnetometer increases as the mass of the susceptible material increases. The response quickly decreases as the distance between the magnetometer and the susceptible object increases. In addition, the magnetic signature of any material is a combination of its induced and permanent magnetic field. This makes quantitative interpretation difficult since the permanent magnetism of an object is variable and its induced magnetism is dependent upon the condition of the material in question (i.e., degree of corrosion of old drums.) The orientation and shape of the debris will also affect its magnetic signature. Magnetic anomalies may be positive or negative in sign, or both, depending upon the target depth, orientation and other variables. These factors combine to make any quantitative analysis extremely complex.

## LOCATING FROM QUALITATIVE INTERPRETATION

Under normal circumstances, a useful qualitative interpretation is generally achieved. The aim of the qualitative interpretation is to identify areas of probable metallic debris rather than to explicitly resolve the source of the magnetic anomaly. In the northern hemisphere mid-latitudes, magnetic anomalies from buried metallic debris usually have both a positive and negative component. The positive component of an individual anomaly usually lies to the south of the buried object, while the negative component lies to the north. The horizontal location of the buried metallic mass generally lies between the positive and negative components of an individual anomaly.

## **GROUND PENETRATING RADAR SURVEYS**

### **GENERAL**

Ground Penetrating Radar (GPR) instruments transmit, receive, and record subsurface electromagnetic signals at frequencies ranging from 80 MHz to over 1000 MHz. They function very much like conventional radar; conductive objects below the surface reflect the transmitted electromagnetic signal, and a receiver detects the reflected signal which is recorded or stored by the instrument. The signal is recorded using a strip chart recording unit, and the result is a continuous profile of the radar signal.

The depth of investigation of the GPR is dependent upon the depth of penetration of the emitted radar signal. The penetration depth of the radar signal is limited in areas of high near-surface conductivity. This typically includes areas which have near-surface materials containing a large percentage of clay and/or silt, as well as highly saline ground water. The penetration depth of the GPR is generally unaffected by concrete slabs unless a large amount of closely spaced steel reinforcement is present.

### **BURIED OBJECTS**

Since metallic objects present in the subsurface represent a substantial change in conductivity relative to typical soils, radar signals are strongly reflected from buried metallic objects. The size and shape of the reflected radar signal are used to evaluate the type of object causing the reflection. Buried underground storage tanks (UST's) usually generate a very diagnostic hyperbolic-shaped radar reflection when surveyed perpendicular to the long axis of the UST. The time required for the radar to travel to the UST and back allows an estimate to be made of the depth of burial of the UST.

### **STRATIGRAPHIC APPLICATION**

The GPR can also be used to map subsurface stratigraphy, bedrock, fill zones, and depth to water table. Changes in subsurface conductivity which are related to stratigraphy can be imaged by the GPR yielding a cross section of subsurface conductivity variation. Typical stratigraphic related conductivity variations include the degree of water saturation and salinity, and clay content. The GPR has also been used to successfully map subsurface contaminant plumes such as hydrocarbons floating on the water table.

### **DATA INTERPRETATION**

Interpretation of the recorded data utilizes time-distance relationships between the ground surface and subsurface changes in conductivity which reflect the radar signal. In general, the greater the time interval between transmission and reception of the radar signal, the greater the depth of the conductivity change or reflector.

## INSTRUMENT DESCRIPTION

The GSSI SIR System 3 Radar consists of a transducer (transmitter/receiver), a console/recorder, a control cable and a remote marker. The recorder is approximately 18" by 18" by 9" and weighs about 40 pounds. The console consists of the electronic controls for generating the radar signal and for filtering, amplifying, and recording the data.

The transducers vary in size and shape. The units are small enough to be moved by one person. Some are dragged across the ground surface, others roll on wheels. The transducer is connected to the control unit using a 100-foot cable.

## INITIAL SET-UP AND CALIBRATION

- Connect power cable and control cable to the console.
- Connect the control cable to the transducer and attach the remote marker to the transducer.
- Set the instrument switch positions as follows:

Power	OFF
Print Polarity	$\pm$
Paper Take-Up	AUTO
Lines/Inch	100
Scans/Sec	16
Surface	Adjust to site conditions
Center	Adjust to site conditions
Deep	Adjust to site conditions
Range	Adjust to survey objectives
Calibrator/Marker	CENTER POSITION
Range 100/1000	Adjust to survey objectives
Radar Speed	<u>X1</u>
Marker	FULL
Scale Lines	ON
Threshold	50%
Filters	<u>10, 50</u>
Auto/Manual	AUTO
XMIT Rate	<u>50</u>
Mode	<u>RADAR</u>
Clock	<u>INT</u>
Print/Stby/Remote	STBY

- Turn the power on.
- Locate the transducer at the survey area and adjust the gain settings using the procedure outlined in the manual.
- Switch the calibrator/marker switch up, and record the calibrator signal.

## **DATA COLLECTION**

Data are collected by walking the transducer at a relatively constant speed over chosen profile lines at the site. Each of the records must be labeled, and the location of the profile noted. Marks should be placed on the record at a minimum of 10-foot intervals.

Survey locations will be gridded in the field. Specific areas of interest may be surveyed in greater detail. A set of field parameters must be defined, and those settings should be used at all locations.

## **DOCUMENTATION**

The instrument generates analog paper records. These records will be marked and any notes will be copied to each individual record. Daily notes will also be gathered.

## **SOIL BORING DRILLING USING HOLLOW-STEM AUGERS**

### **Introduction:**

When the primary objective of the drilling is to obtain soil samples from discreet depths, the hollow stem augering (HSA) technique of drilling is one of the most effective. The soil is penetrated with five-foot-long, continuous helical flight augers which are driven by a rotary drive head mounted on a hydraulic feed system which pushes the drill stem down or pulls it up. Cuttings are mechanically removed from the borehole by the flights on the HSA's.

### **Goal:**

To drill a soil boring from which the depths and descriptions of the soils encountered can be accurately logged and to obtain samples of the soils from accurate soil depth intervals.

### **Task-Specific Equipment Needed:**

1. All drilling equipment and labor are supplied by the subcontracted drilling company.

### **Procedure:**

1. Access the drill rig and all necessary equipment to the proposed borehole location.
2. Advance the HSA's to the top of the proposed soil sampling depth.
3. With the augers in place and at rest, remove the center plug from the inside of the augers.
4. Attach a decontaminated split-spoon sampling or other device to the drilling rods.
5. Lower the device inside the HSA to the bottom of the borehole.
6. Drive the device into the soil as described, for example, in the WWES' Standard Operating Procedure (SOP) for "Split-spoon Sampling".
7. Recover the device.
8. Replace the plug inside the HSA and continue drilling to the next sampling depth.
9. When the desired completion depth has been attained, properly backfill the borehole from the bottom up as described in WWES's SOP for "Soil Boring Grouting" and decontaminate the drilling and sampling tools according to the SOP "Decontamination, Downhole Sampling Equipment".

Unless there is a specific need for another size auger, WWES's standard is to drill soil borings with 4.25 - inch inside diameter HSA's. The outside diameter of these augers is 8.25 inches.

## DECONTAMINATION, DOWNHOLE SAMPLING EQUIPMENT

This guideline consists of minimum requirements for the decontamination of split-spoon sampling devices, temporary well materials, augers, and water sampling bailers used at hazardous waste sites for obtaining samples to be analyzed in the laboratory.

The requirements apply foremost to equipment being used to obtain samples for the laboratory and, therefore, are intended to minimize incidents of cross-contamination of samples. The requirements also apply to the auger where contaminated soils are sampled only for on-site identification purposes. This is to avoid cross-contamination of locations. The requirements apply to the auger, particularly when moving from a "dirty" to a "clean" location.

### ANALYTE TYPES

Different decontamination steps are recommended for different kinds and physical states of analytes. The analyte types for this purpose are:

- . **inorganics**--major dissolved ions, along with heavy metals.
- . **dissolved organics**--organics as aqueous species, no "free" organic phase present.
  - (1) *soluble organics*--ketones, alcohols, ethers, and others that are fairly to infinitely soluble in water
  - (2) *VOC's*--sparingly soluble
  - (3) *semi-volatiles*--sparingly soluble
  - (4) *PCB's and pesticides*--nearly insoluble in water, but very soluble in oil
- . **free organics**--a visible or suspected organic liquid phase. This is usually not an analyte, but when present interferes with analysis of the aqueous phase compounds and presents a strong potential for cross-contamination.
- . **combination**

The decontamination procedures apply to equipment in contact with analytes whether present within a soil matrix or as a "free" liquid.

### DECONTAMINATION FREQUENCY

The lead auger (and any flites affected by formation heave) should be decontaminated between each location. The split-spoon sampler, temporary well materials, and bailers should be decontaminated between each use. Well evacuation followed immediately by sampling would be considered a single use of a bailer. If two or more wells are consecutively evacuated prior to any sampling, or if there is a delay between evacuation and sampling the well, the bailer should be decontaminated after each evacuation. With a



few exceptions to be mentioned, all named equipment should receive the same kind of decontamination.

## **DECONTAMINATION PROCEDURES**

The recommended decontamination steps are given in the accompanying table.

Where soluble organics, VOC's or semi-volatiles are present, the least time consuming decontamination method is steam cleaning. Although tap water is typically used for steam cleaning, no final DI rinse should be required because the steam should be at an elevated temperature which enhances the removal of volatiles. Steam cleaning should be always conducted at "live steam" temperatures, which exceed 212°F. Be sure the steamer water is taken from a public water supply or a source of known and approved quality. If you know or suspect that unvaporized water is carrying over, use a final DI rinse or halt work until the steamer is performing as it should. Also, be sure the steam delivery wand is of sufficient length to deliver live steam to remote points (e.g., center of 20-foot pipe section).

The inorganics and heavy metals call for an initial soapy wash, tap water rinse, dilute acid rinse, and a final DI rinse. The "soap" for the soapy wash can be a TSP (trisodium phosphate) product. If phosphate or phosphorus is an analyte, or otherwise disadvantageous, a low-phosphate detergent, such as Alconox, may be used, followed by a dilute acid rinse and a DI rinse. The dilute acid for the inorganic rinse, and to remove any traces of phosphate detergent where necessary, can be reagent grade nitric or hydrochloric acid of 0.01 normal strength.

The PCB's, pesticides, and free organic phase contaminants call for solvent rinses following a soapy wash, and immediately preceding the final DI rinse. An alternative to performing the final DI rinse following a methanol or acetone rinse is to apply live steam to the equipment to volatilize these compounds.

## **DISPOSAL OF DECONTAMINATION WATERS**

In general, all spent wash and rinse waters including organic rinse liquids will be contained to prevent them from being returned to the ground. All decontamination liquids, along with other incidental waters such as well-development or well evacuation water, will be appropriately disposal. Disposal arrangements or plans will be developed prior to the work, where feasible, and with the client's input and concurrence. Appropriate disposal for liquids, **except for hexane**, may involve disposal to a sanitary sewer or disposal to an industrial wastewater treatment system.

## **RECOMMENDED FREQUENCY OF CHANGING SOAPY WASH WATER AND TAP WATER**

The cleanest way to perform soap and tap water decon is to have a squirt bottle, sprayer or other applicator for the soapy water, and a flowing stream of tap water. In this manner, the soapy water and tap water "reservoirs" are always clean, and equipment comes in contact with clean solutions only.

If you have to use a tub or dip tank for immersion of equipment in soapy water, the following is offered. Related to the frequency of change is the order in which equipment should be decontaminated. Some general guidelines to minimizing the needed changes:

- Wash cleaner (less soiled or "oily") equipment first.
- Have several split-spoon samplers on hand where practical, to save decontamination time and to allow washing these in a batch before the auger needs to be washed.
- Wash bailers in a dedicated soapy solution. This should not often be inconvenient since drilling/soil sampling is usually done separately from well sampling. Having several bailers on hand can allow batch washing of them before a dirtier piece of equipment needs to be washed.
- Wash temporary well casing and screens in a soapy solution dedicated to these materials only.

If a tap water stream is impractical, change the tap water when it first shows discoloration, floating debris, or foaming tendencies due to soap carryover. Two tap water baths in series, changing out both when the second bath reaches the above condition, will minimize changes.

Change soapy water when you change the rinse bath, sooner if the soapy water shows a slick that is other than detergent film. Change soapy water when the solution is too "spent" to generate soap/detergent foam with moderate agitation. If, before any of the above indications occurs, the soap solution becomes discolored with suspended clay or silt, it becomes a matter of personal judgment. It is a good idea to have sufficient drum capacity on hand to be able to change the soapy water "more" frequently rather than "less". Be sensitive to aesthetics and impression as well, when the client's representatives or regulatory personnel are on site, and be prepared for more frequent changes than your experience might otherwise dictate.

## FIELD NOTES/RECORDS

Each week field notes must be copied to the Project Manager, or the Project Engineer/Geologist. Don't invest time in editing or rewriting them; the notes should have been taken throughout the day and, therefore, they should be a sufficiently accurate record in their original form.

The best time to copy the notes would be with the lab copier as you are turning in samples at the lab receiving desk, or, at Eagle Drive when returning equipment.

By providing the copies weekly, the Project Manager will have timely information and can begin to get any of his questions about the notes answered right away.

### NOTES MUST INCLUDE:

- 1) Project Name
- 2) Project Number
- 3) Technician's Name
- 4) Date
- 5) Location of Field Activity (for example, Lansing, corner N. Logan and Sunset)
- 6) Materials and Equipment - list, including the quantities on-site at the beginning of each day
- 7) Weather - limited information (sunny, overcast, humid, precipitation, wind, approximate temperature)
- 8) Methods, Brief - "according to work plan". If deviation from plan, you must note what was done differently, why, and the results. You must note whether the deviation was called for by you, or a departure by the contractor. If by the contractor, whether you have approved or disapproved it.
- 9) Problems Encountered - how they were dealt with. Problems include equipment malfunction, delays, unsafe working conditions or procedures, departure from the Health & Safety Plan, attitudes/comments of workers/visitors, weather adversely affecting the work, and inspected work found to be unsatisfactory. Include a sketch of an unusual procedure, if helpful.
- 10) Site Visitors - who and when, their comments
- 11) Location Descriptions - wells, borings, and sampling stations. Distance tie-in to two fixed site facilities.

- 12) **Summary of Work Accomplished** - For example, locations completed (such as borings B-1, B-9; well 3-A), soil volume removed, depth of drilling in progress.

Concerning the numbered items of information above:

- **Record Items 1 through 7 right away. Item 6 is optional, depending upon the manager and project needs.**
- **Record Items 7 through 11 during the day, as any changing weather and site events call for. Record Item 11 only if locations are not documented elsewhere.**
- **Attend to Item 12 at the end of the working day.**

**Notes must reference any forms used for documenting calculations, location descriptions, depth measurements, and time and materials. For example:**

Sampling Calculations--see attached WSFR form

Well/Boring Elevations--see attached survey form

Water Level Data--see attached WL & FR forms

Time and Materials--see attached DT & MR form

**Attach the original filled-out forms with copies of the notes.**

**WELL/BORING LOG GUIDELINES**

For every well or soil boring, a separate well/boring log sheet must be completed using our standardized well/boring log sheet. On the top half of the sheet are a number of headings with accompanying blanks. It is imperative that all applicable information in this top area be filled out completely for each well or boring.

**Well/Boring No.:** The numbering sequence is generally provided by the project manager and must be recorded accordingly.

**Client:** Record the client or project name.

**County-Township-Fraction-Section:** This information can be filled out at the office by the project geologist.

**Contractor:** Give the name of the contractor. Include their complete address. The equipment used should be documented. If a drill rig was used, record the make and the model. The name of the drilling crew chief should also appear here. The supervisor would be the WWES person responsible for overseeing the work in the field.

**Drilling Methods:** Record the method of drilling that was used. Also, record the diameters of the drill string. Some examples would be:

- 4 1/4" I.D. HSA (inside diameter hollow stem auger)
- 10" O.D. HSA (outside diameter hollow stem auger)
- 3-1/8" mud rotary
- 5-1/2" O.D. x 3-1/4" I.D. dual wall reverse air circulation
- 4" O.D. hand auger

**Grouting/Seal:** Record the grouting material and the grouting method. If an additive is used, estimate its weight percentage. Also, record the bottom and top depths of the grout.

**Development:** Include the developing method, rate, pumping time, and total volume evacuated from the well.

**Screen:** Each item needs to be completed as described on the sheet.

**Casing:** Record the casing material, diameter, and the bottom and top depths of the casing. A "+" value indicates above-ground well stick-up. An "0" value indicates a flush-mount well. Record the top of well thread distance to grade to the nearest 0.1 foot.

**Date:** Record as indicated on the sheet.

**Elevation:** Survey elevation data should be recorded here if you have this information. Be sure to include the reference point whether it is U.S.G.S. datum or a relative elevation. Include the location of your reference point. This information may not always be available to you as the drilling takes place, and it may need to be filled in at a later date by others.

**Water Level:** In a soil boring, record the first water-saturated level encountered and the elapsed time before measurement. In a well, record the water level using the top of casing as the reference point and note TOC. Also, record the date of the measurement, the time elapsed since development, and the method of measurement.

**Location:** Reference your sketch and measurements to features evident on the base map which the project manager has supplied. If no base map has been supplied, reference your measurements to permanent site structures.

**Well Sketch:** Somewhere on the log sheet, a sketch of the well construction should be drawn. On this sketch, show the amount of above-ground stick-up, the depths to joints along the well casing, and the depth of the top and bottom of the well screen.

**Remarks:** Any added comments that are unique to the boring or well can be recorded here.

On the lower half of the well/boring log sheet is an area for the lithologic description. The soils or rocks that are penetrated during drilling should be recorded as accurately as possible according to the soils classification guidelines. On the left side of the log sheet, a number should be recorded in the thickness and the depth to base columns for every lithologic change recorded in the lithologic descriptions.

The remarks area in this lower portion should be used to clearly identify soil sample depths, blow counts, and any other readings or measurements taken at individual depth intervals (Hnu, OVA).

**Date:**  
**Started:** \_\_\_\_\_ **Finished:** \_\_\_\_\_

Contractor \_\_\_\_\_  
Address: \_\_\_\_\_  
\_\_\_\_\_  
Equipment: \_\_\_\_\_  
Crew Chief: \_\_\_\_\_  
WW Supervisor: \_\_\_\_\_

Drilling Method(s)	Depth
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1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement.

**Remarks** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Water Level** \_\_\_\_\_ **Ft. Below** \_\_\_\_\_

[illegible]

# Log of Well Installation

Well Designation: \_\_\_\_\_

Date(s) of Installation \_\_\_\_\_ To \_\_\_\_\_

Generalized  
Subsurface  
Profile

Length of Casing Above Ground Surface

Concrete Cap (Y/N)

Depth to Top of Grout/Backfill (circle one)   
Grout Material \_\_\_\_\_

Depth to Top of Bentonite Pellets/Slurry (Circle One)

Depth to Top of Filter Pack   
Type \_\_\_\_\_

Depth to Bottom of Well Screen

Borehole Backfill Material

Total Depth of Borehole

Top of Casing Elevation:

Ground Surface Elevation:

## Water Level Data

Date Water Level Below TOC

<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>

Development : \_\_\_\_\_

Survey Reference: \_\_\_\_\_

Well  
Casing

Diameter: \_\_\_\_\_  
Total Length: \_\_\_\_\_  
Material: \_\_\_\_\_  
Cap Type: \_\_\_\_\_

Well  
Screen

Diameter: \_\_\_\_\_  
Length: \_\_\_\_\_  
Slot/Type: \_\_\_\_\_  
Material: \_\_\_\_\_

Protective  
Well Casing

Material: \_\_\_\_\_ Dia. \_\_\_\_\_  
Height Above Ground: \_\_\_\_\_  
Lock Type: \_\_\_\_\_

General Notes: \_\_\_\_\_



## SOILS CLASSIFICATION

There are several different soils classification systems. In order to maintain a level of consistency on our logs, WWES has adopted a modified form of the Wentworth Scale as our standard for soil descriptions:

Each soil description should follow a consistent order; that order is:

- 1 texture
  - a) basic
  - b) modifying
- 2 consistency
- 3 color
- 4 water content  
(odor, organic soils, organic liquids, interlayering)

### **BASIC TEXTURE**

PARTICLE SIZE	BASIC TEXTURE DESCRIPTION TO USE
larger than 10 inches	Boulders
3 inches to 10 inches	Cobbles
1 inch to 3 inches	Gravel - Coarse
2 mm to 1 inch	Gravel - Fine
0.5 mm to 2 mm (size of pencil lead)	Sand - Coarse
0.2 mm to 0.5 mm (size of table sugar)	Sand - Medium
0.06 mm to 0.2 mm (size of powdered sugar)	Sand - Fine
0.004 mm to 0.06 mm	Silt
<0.004	Clay
	Organics - define as peat, muck, coal, twig, etc.

### **MODIFYING TEXTURE**

Give estimates of the modifying texture content by using the standard adjectives, as outlined:

ESTIMATED PERCENTAGE OF THE MODIFYING TEXTURE	ADJECTIVE TO USE
1 - 10%	Trace
11 - 35%	Some
35 - 50%	And

Give approximate particle size for coarse gravel and coarser grades of particles encountered. Cobbles and boulders may be described as "occasional".

## CONSISTENCY

The consistency description is somewhat redundant since the blow counts for each sample are recorded. This part of the description may be omitted as long as the blow counts are documented on the well/boring log sheet. Otherwise, make the consistency description from the following:

BLOWS PER 6 INCHES COHESIVE SOILS (CLAYS)	CONSISTENCY DESCRIPTION TO USE	OF GRANULAR SOILS (SANDS)	DENSITY DESCRIPTION
0 to 2	very soft	0 - 4	very loose
2 to 4	soft	5 - 10	loose
4 to 8	medium soft	11 - 30	medium dense
8 to 15	stiff	31 - 50	dense
10 to 30	very stiff	over 50	very dense
over 30	hard		

## COLOR

Record the color as you see it. The color description may be modified by an adjective such as light or dark. If there are two major but distinct colors in the soil, describe the color as mottled (i.e., brown mottled gray).

## WATER CONTENT

A description of the water content follows every soil description.

The three adjectives to use are:

### WATER CONTENT

Dry  
Moist  
Wet

### SAMPLE CHARACTERISTICS

powdery or hard  
plastic or containing some liquid  
saturated or puddles when shaken

Adjectives such as slightly moist may be used if necessary.

Be sure the sample is thoroughly saturated when describing a wet sample.

**Examples:**

1. SAND, fine to medium, some silt, trace clay, light brown, wet.
2. CLAY, some silt, trace medium to fine sand, brown mottled gray, moist.
3. SILT, trace fine sand, yellow-brown, dry.
4. CLAY, some silt, trace CSE gravel (2 inches), occasional cobble (8 inches), gray, dry.

Each log should be as accurate as possible. The frequency of soil sampling should be reflected in the detail of the well/boring log. The log for a borehole sampled continuously will be much more detailed in both soil descriptions and depths to soil changes than a log for the borehole in which no soil samples were taken.

Well/boring log forms must be completed for every well or boring installed, regardless of depth or method used, even if the project manager has not specifically requested it.

## **JAR HEADSPACE MEASUREMENTS IN UNSATURATED SOIL SAMPLES**

### **(USING FID OR PID)<sup>(1)</sup>**

#### **Introduction:**

This procedure is most commonly used at sites where there is a suspected impact from gasoline constituents. The two instruments most commonly used for this field procedure are a flame ionization detector (FID) and a photoionization detector (PID). The FID response is uniform for most volatile gasoline hydrocarbons while the PID response increases for the BTEX compounds. Therefore, the PID may be more effective when concentrating on the aromatic constituents of gasoline.

Most field devices are sensitive to changing weather, and the response of the PID may become significantly affected by an increase in the humidity.

The FID systems, unlike the PID systems, will respond to methane.

#### **Goal:**

To obtain a field estimate of the relative concentrations of total volatile organic compounds (VOC's) contained within a soil sample.

#### **Task-Specific Equipment Needed:**

1. Flame ionization detector (FID) or a photoionization detector (PID) equipped with a 10.2 eV lamp (HNU brand) or 10.0 eV lamp (Thermo Environmental Instruments - OVM/Datalogger).
2. Glass sample jars between 9 and 16 ounces in total capacity.
3. Aluminum foil.

#### **Procedure:**

1. Calibrate the FID or the PID as indicated in the instrument manual.
2. Record the calibration procedure and the calibration results in the field notes. If a dedicated log book accompanies the instrument, record the calibration details in it.
3. Collect the soil sample.
4. Place the soil sample into the glass sample jar immediately. Fill the sample jar half-full.
5. Seal the sample jar by placing a clean piece of aluminum foil over the mouth and threads of the jar.
6. Allow the sample to reach approximately 70°F.
7. After a 5- to 10-minute headspace development period, vigorously agitate the sample jar for at least 30 seconds.
8. Immediately insert the probe of the FID or PID through the aluminum foil seal and into the sample jar.
9. Record the maximum meter response as the TOTAL ORGANIC VAPOR HEADSPACE concentration on the Well/Boring log form or the field notes as appropriate.
10. Record any significant changes in the weather (and the apparent humidity) that occur throughout the day.

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(1) John Fitzgerald, Petroleum Contaminants in Soil, Vol. II, pp. 119-135.

## **FIELD QC SAMPLE GUIDELINES**

The following is for guidance to ESD staff who are making decisions in the work plan preparation phase of projects. This guidance applies to projects and clients that may not require field QC samples, but may benefit from the inclusion of them in the sampling plan as circumstances dictate.

With each new project, a conscious decision should be made whether to include QC samples. Agency requirements (e.g., the MDNR Waste Management Division Geotechnical Unit) may be specific for field QC samples. Therefore, be aware of agency requirements when responding to your client's ordered investigation.

### **TRIP BLANKS**

Trip Blanks (organic free water samples in VOC vials placed in lab chest), are renewed each time a chest is packed or repacked with VOC sample containers. These samples remain unopened in the chest. If these "blanks" show "detectable" for one or more compounds, the problem could be cross-contamination between sample and container via air in the chest, or lab contamination.

Be sure these are packed with other volatile organic sample containers when five or more VOC samples will be taken that day, or when two or more sites will be visited on the same sampling trip. If possible, VOC sample containers should be packed and shipped in their own small cooler. VOC sample containers should definitely be separated from other sample containers that are visibly contaminated or "smell".

Analyze the trip blank for phthalates if base neutral compounds are to be run. These are contaminants that can enter samples from "plastic" lab containers and other sources. The laboratory provides trip blanks with every set of semi-volatile bottles.

Trip blank samples need not be analyzed routinely. But if a reported analysis is suspect, the blank can be run. Bear in mind that the value of a blank sample "on hold" decreases with time beyond one or two weeks due to possible communication by other samples via the lab air, and due to holding-time considerations.

### **FIELD BLANKS**

Field Blanks are VOC vials filled in the field sampling area with organic-free water. This is done most often when the work site shows Hnu readings above the off-site background, or when local background readings can be established as non-zero.

Take one or more of these if the air screening instrument reads 2 ppm or higher above the background in the work area at any time during the day (not including sample-specific readings). This assumes instruments are calibrated in an off-site, clean-air area, where

volatile contaminants are non-detect. The high air concentrations can be due to a persistent site condition, or to the presence of volatiles only at times of drilling and surfacing of contaminated subsoils or ground water. Field blanks should also be collected in conjunction with samples where there are vehicles or heavy equipment operating nearby, or when there is noticeable particulate matter.

Pack extra VOC vials, along with organic-free water in a non-reactive container. Obtain one or more blanks during the day by filling and sealing VOC vials with organic-free water while in the work zone. Leave the water container firmly closed otherwise. Analyze the blank taken at the time or closest to the time of the highest work-zone reading made during the day. Additional blanks may be run if conditions warrant.

The field blanks for sampling events involving water VOC samples, and for soil VOC samples prepared by adding organic-free water to a partially soil-filled vial, should be taken if site air readings are 2 ppm or more above ND background. For the usual method of collecting soils by completely filling the vial with soil and without adding water, the threshold may be 5 ppm or more above ND background.

### **EQUIPMENT RINSE BLANKS**

Equipment Rinse Blanks are rinse water samples obtained after the final planned rinsing step for decontamination of bailers, split spoons, lead auger, etc. These blanks demonstrate that the non-dedicated sampling equipment has been thoroughly cleaned and that the sample collection and handling process has not altered the quality of the sample. These blanks typically include containers for all of the pollutant groups being analyzed. This kind of blank is most effective in demonstrating decontamination thoroughness when accompanied by a "before" rinse sample of organic-free water passed through the device immediately after using the equipment.

A field-filtering blank should be collected when samples are filtered in the field.

### **UTILITY WATER SAMPLES**

Utility Water (for drilling fluid make-up, wash/rinse water, etc.) samples should be taken for VOC analysis whenever a new or different source is used. If a source is used for which prior water quality knowledge is unavailable, it is a good idea to run all of the analytical groups being investigated.

Run one sample early in the investigation for all investigative groups unless existing data for the specific source valve indicate there is no need. If any compounds are detectable, rerun a sample of the final tank (drum) for those compounds. Alternatively, find an uncontaminated source of utility water.

## DUPLICATE SAMPLES

Under any of the following conditions, obtain duplicate samples:

- 1) Each day seven or more investigative samples will be taken.
- 2) One duplicate for each ten samples during the day plus a duplicate sample beyond ten or a multiple.

Example: 0-6 samples during the day	0 duplicates
7-10 samples during the day	1 duplicate
11-20 samples during the day	2 duplicates
21-30 samples during the day	3 duplicates

This means the analytical cost for duplicate samples where seven or more investigative samples are taken will add between 10 and 18 percent to the cost of the investigative samples. Lab discounts for multiple samples will help reduce the cost.

Duplicates may not be needed when a site will be sampled repeatedly, as with a quarterly monitoring sampling schedule.

## SPECIAL CONSIDERATIONS FOR DUPLICATE SOIL SAMPLES

Obtain soil (or waste) duplicate samples at the same frequency as water samples. Because of the time required to perform some operations frequently involved with soil sampling--for example, obtaining a partial sample for later head-space screening; splitting the core and discarding "stones"; or describing a particularly detailed core--they can result in differential loss of VOC's from partial samples taken as duplicates. For this reason, volatile organic analyses from duplicate samples can disagree widely. To avoid this, care should be taken to handle duplicate VOC samples in the same manner as the investigative samples, especially the elapsed time between sample collection and sealing of the vials.

Additional problems with soil duplicates include the mass of soil needed for analysis (which sometimes exceeds the volume/mass in the sampler), and the difficulty of obtaining two separate split spoon samples at the same level for use as duplicates. Careful planning needs to be done when volatiles or a critical number of priority pollutant groups are to be analyzed.

The purpose of the duplicate samples should be clear before going to the field. If the purpose is to verify the sample handling and analytical procedures, then a split sample should be collected as a duplicate. If, however, the sampling methodology is to be verified, then a totally separate sample from a closely adjacent or offset location should be collected.

## **SOIL BORING GROUTING**

### **GENERAL:**

#### **NON-SOURCE AREA**

It is WWES' standard to grout any borehole which penetrates a clay layer. When water bearing bedrock is within 25 feet of the land surface, all boreholes should be grouted. If the only soil encountered is granular, soil cuttings or natural soil cuttings mixed with a granular bentonite may be used to backfill the boring.

#### **SOURCE AREA**

Backfill all boreholes with a grout that is free of soil cuttings.

For the grouting procedure used when constructing monitoring wells, see the SOP for the "Installation of Permanent Monitor Wells with Hollow Stem Augers."

### **GOALS:**

1. Maintain the integrity of any aquifer encountered.
2. Create a seal less permeable than any natural strata penetrated.
3. Eliminate the borehole as a preferred conduit to lower strata.

The need for grouting depends on several factors. These factors include the geologic conditions of the site, the impact or potential for impact from contamination sources, the drilling methods used, and regulatory requirements.

Grouting becomes increasingly important when contaminated formations are penetrated, bedrock is close to the surface, bedrock is highly fractured, ground water protective strata such as clay have been penetrated, or artesian conditions are present.

There are basically two types of grout that are in common use for drilling procedures in Michigan. The first is a neat cement or neat cement/bentonite grout which is most applicable to the requirements for borehole and monitoring well installations. The second is a high-solids bentonite grout which is also acceptable but involves procedures which can be difficult to perform.



### **PROPERTIES:**

A neat cement grout is composed of Type I Portland cement and fresh water; no aggregate is present. The cement used should be regular cement. Air entraining cement should not be used as it is designed to capture tiny air bubbles as it sets and, therefore, increases the porosity of the grout.

Mixed in the proper ratio (6 gallons of water to one bag of cement), neat cement has been demonstrated to have a permeability of about  $10^{-7}$  cm/sec.

Up to 5% bentonite by weight may be added to the neat cement grout. The addition of bentonite gives the advantages of:

1. Increasing the set volume of the grout.
2. Decreasing grout shrinkage.
3. Decreasing grout density.
4. Inhibiting water loss from the grout.

The act of mixing and placing grout is the responsibility of the drilling contractor. The Field Technician is responsible, however, to see that proper mixing and placement techniques are followed.

### **PROCEDURE:**

1. Mix the grout with a proper water/cement ratio (the proper ratios are given in the attached table).
2. Pump the grout into the annulus in one continuous action before initial setting occurs. The grout should be pumped through a tremie rod or some other conduit so that the grout fills the annular space from the bottom up. This reduces contamination or dilution of the grout, and assures a complete seal.
3. Continue pumping until the grout is visually observed returning up the annulus at the ground surface.
4. Pull the augers while adding grout from the surface as needed.

5. Document the grouting procedure in the field notes, which should include:

- depths to the top and bottom of the grout column
- type of grout used
- estimated percentage by weight of any additives
- water/cement ratio
- method used
- total amount of grout used
- explanations of any deviations from the standard procedures

If drilling is to resume inside a surface casing which has been grouted in place, it is recommended that 72 hours of set time be allowed to elapse before drilling resumes.

**WATER/CEMENT RATIOS  
AND  
SLURRY DENSITIES**

<b>GROUT REQUIRED</b>	<b>MIX TO USE</b>			<b>MINIMUM DENSITY (lbs/gal)</b>	<b>VOLUME (ft<sup>3</sup>/bag)</b>
	<b>WATER (gals)</b>	<b>CEMENT (94-lb bags)</b>	<b>BENTONITE (lbs)</b>		
neat cement	6.0	1	0	15.0	1.28*
neat cement & 1% bentonite	6.0	1	1.4	15.0	1.27
neat cement & 2% bentonite	6.5	1	3.0	14.7	1.36*
neat cement & 3% bentonite	7.2	1	4.6	14.4	1.45
neat cement & 4% bentonite	7.8	1	6.4	14.1	1.55*
neat cement & 5% bentonite	8.5	1	8.2	13.8	1.64
Bentonite: Benseal/Aqua-Grout (Bariod Products)	1	0	1.5	9.25	4.75
Bentonite: Benseal/Quick-Gel (Bariod Products)	1	0	0.2	9.25	5.0
Volclay	1	0	2.1	9.4	3.6

\*From Haliburton Services, 1981

(Reference: Michigan Water Well Grouting Manual, MDPH)

**Typical Weights:**

1 bag cement = 94 lbs

1 bag bentonite = 50 lbs

## **INSTALLATION OF PERMANENT MONITOR WELLS** **WITH HOLLOW STEM AUGERS**

The objective of any monitor well installation is to obtain a representative ground water sample from a desired depth interval. That sample should be obtained with a minimum of disturbance to the soil, ground water flow, and ground water chemistry in the aquifer. To meet this objective can be challenging but well worth the effort.

Using hollow stem augers (HSA) to install a monitor well does have advantages:

- The use of drilling fluids above the water table is not required.
- Accurate, undisturbed soil samples are obtainable.
- The water table is easily detected.
- The augers create a temporary casing within which the well can be constructed.

There are also disadvantages:

- The augers are useful only in relatively soft drilling conditions.
- Augers are limited to relatively shallow depths.
- It is usually necessary to introduce water or mud to advance a boring once a significant aquifer has been encountered.

### **PROCEDURE:**

In ideal conditions, the construction of a monitor well inside the augers is straightforward:

1. Advance the HSA to the desired depth.
2. Remove the center plug.
3. Install the steam-cleaned well.
4. Seal all the well joints with Teflon tape.

5. Set the well screen on the bottom of the hole. Pour the coarse grade sand inside the HSA to fill the annulus between the well screen and the borehole as the augers are pulled back. The sand pack should extend at least 1 to 2 feet above the top of the screen.
6. Pull the bottom of the auger string back to a depth just above the sand pack.
7. Seal the sand pack from the upper portion of the remaining borehole annulus with 1 foot of pelletized or coarse grade bentonite placed above the sand pack.
8. Pull the bottom of the auger string back to a depth just above the bentonite seal.
9. Tremie grout the remaining annular space. (The inside diameter of the augers has been carefully selected to allow enough room for a tremie rod to be lowered along the well casing inside the augers.) A cement/bentonite grout is mixed at the surface and pressure pumped down through the tremie rod to fill the annular space from the bentonite seal up to a depth of 2 feet below the land surface.
10. Finish the well construction at the ground surface with either a locking flush-mount cap or a locking protective casing set in concrete which slopes away from the well diverting any surface water from the well casing.
11. Develop the well until sediment-free water is produced. The well should be developed by a method which surges water into and out of the screen until relatively particle-free water is produced. It is best to perform the development after the grout has set.

Since ideal conditions are rarely encountered in the field, there are several factors which may cause a deviation from the ideal well configuration. These factors may necessitate the elimination of the sand pack or the bentonite seal, or both. In some cases, allowing the natural collapse of the saturated soil around the well screen provides sufficient sand pack for the well screen.

Proper placement of a bentonite seal for well screens placed far below the top of the water table can also prove impractical. In these cases, the bentonite seal may be forfeited to assure that the cement/bentonite grout will be properly placed with a tremie rod.

If the hollow stem I.D. will not allow a tremie rod, a clean flexible hose may be lightly taped to the length of the well casing prior to insertion to provide a conduit for delivering grout at depth.

All well construction data will be recorded on the standard well/boring log forms.

## **MONITORING WELL SAMPLING WITH A BAILER**

The objective in well sampling is to obtain a representative sample of the ground water from the formation where the well screen has been placed.

### **JOB DESCRIPTION:**

Obtain ground water samples from the specified wells.

### **TASK-SPECIFIC EQUIPMENT AND MINIMUM INFORMATION NEEDED:**

- detailed well location map
- order of the well sampling  
(supplied by the project manager)
- polypropylene rope
- bailers
- container for purge water (if required)
- well keys
- total well depth data
- water level tape (electric or steel)
- well pumps if necessary
- previous water level data
- disposable gloves
- sample bottles
- calculator
- $V = Hr^2 (0.163)^a$

<sup>a</sup>Refer to guideline for calculating the volume of standing water in a well casing.

### **EXPECTATIONS:**

All water levels will be taken prior to sampling.

All purge volume data will be recorded.

Sound decontamination procedures will be followed.

Noticeable discoloration or odor in the water will be reported.

Each sample requested will be collected.

### **PROCEDURES:**

1. All the wells of a cluster to be sampled are uncapped. Care must be taken not to mix the caps up. The caps should be placed near the well on a clean area, such as a small piece of plastic. Inspect the condition of the well(s).

2. Take a round of water levels. Electric tapes decrease the potential for cross-contamination.
3. Calculate and record the volume of water in the casing. Record the needed purge volume (three times the volume of water in the casing).
4. Purge the well with a clean or dedicated bailer and a new length of polypropylene rope. Concentrate the purging effort at the air/water interface.
5. Record the amount of water actually purged and what was done with the purge water. Record the method of purging, and the type of bailer used (Teflon or stainless steel).
6. Collect the ground water sample with the bailer.
7. Fill the sample container accordingly.
8. Seal the container.
9. If the container is a VOC vial, turn the full container upside down and tap it lightly. Watch for air bubbles. If air is present in the bottle, add more water and recap, again checking for the presence of air bubbles.
10. Label the sample bottle(s) and place in a cooler with ice for transport to the laboratory.
11. Steam clean the bailer before using again.
12. Dispose of the used rope.

In wells which do not readily recover, it may be unreasonable to purge three well casing volumes prior to sampling. In these cases, a field judgment must be made as to what is a "reasonable" amount of time to spend in securing the sample. In a well that can be bailed dry, it is acceptable to purge one casing volume, wait for the well to recover, and take a sample. Keep good records of the volume of water actually purged and estimate the recovery time for the well. The purpose of purging is to remove all the static water from the well. In a well which is bailed dry, that objective is obtained after one well casing volume is removed.



## **SHELBY TUBE SAMPLING**

The Shelby tube sample is taken to determine laboratory permeability characteristics of cohesive soils (clays). The Shelby tube sample is taken in such a way as to minimize disturbance to the sample and to maintain the original moisture content.

The thin wall or Shelby tube sampler is made of seamless steel tubing. Steel construction is usually used because of its strength. Shelby tubes are available in other materials such as brass and stainless steel. Shelby tubes are also available in many diameters and lengths. A 3-inch diameter Shelby tube is the most common and successful size. Tube lengths are generally 24 inches and 36 inches.

### **JOB DESCRIPTION:**

Obtain a Shelby tube sample from a specific stratum.

### **JOB-SPECIFIC EQUIPMENT AND MINIMUM INFORMATION NEEDED:**

- . Depth of layer from which the sample is desired.
- . Materials generally supplied by the driller:
  - Shelby tube
  - plastic end caps
  - glazing compound
  - electrical duct tape
  - Shelby tube to drill rod adaptor

### **EXPECTATIONS:**

Shelby tube sample will be indicated on the boring log.

Shelby tube will be properly labeled and sealed.

### **PROCEDURE:**

The Shelby tube sample is taken in much the same manner as a split-spoon sample:

1. The boring is advanced to the desired sampling depth.
2. The Shelby tube is attached to the bottom of the drill rods and lowered gently to the bottom of the borehole.

3. The tube is carefully pushed into the undisturbed soil ahead of the borehole in one, even, continuous stroke using controlled hydraulic pressure from the drill rig. Excessive pressure will collapse the tube resulting in the loss of a sample.
4. Once the tube has advanced a distance equal to its length or as far as the strength of the tube permits, allow the assembly to rest for 15 minutes. This gives the soils opportunity to expand in the tube and increases the chances for good soil recovery.
5. Rotate the drill rods slowly, approximately two revolutions, to free the soil in the tube from that at the bottom of the tube, and to release any vacuum on the sample.
6. Once the tube is returned to the ground surface, measure and record the amount of sample recovery in the tube.
7. Use the glazing compound to seal the sample from moisture loss. Place adequate amounts of the compound directly against the soil inside both ends of the tube.
8. Place the plastic end caps on the tube and tape them.
9. Label the tube directly, using a permanent marker, with this information:
  - indicate which end is stratigraphically up
  - record the amount of recovery in inches
  - record the sample interval depth
  - record the distance the tube was actually advanced
  - record the well/boring identification number
  - record the date
10. The tube itself is used as the sample container for transport.

**MONITORING WELL PURGING WITH A  
BLADDER, KECK OR ELECTRIC SUBMERSIBLE PUMP**

**GOAL:**

Remove the required volume of water from a well to obtain a sample representative of the natural ground water quality while avoiding cross-contamination.

**TASK-SPECIFIC EQUIPMENT NEEDED:**

1. bladder, Keck, or electric submersible pump
2. water level tape
3. 5-gallon bucket

**PROCEDURE:**

1. Before each well is purged, the outside of the pump and any tubing that goes down the well will be washed with a lab-grade soap, such as Alconox, and rinsed with distilled or deionized water. In addition, some water will be run through the pump to avoid cross-contamination.
2. Measure water level, confirm level with second measurement.
3. Calculate volumes of water to be purged from well. Refer to the well casing volume calculation S.O.P.
4. Lower appropriate pumping unit down the well and position pump intake as near the well water interface as possible. Position outlet hose away from well. It may be necessary to lower the intake hose while purging if the water surface in the well drops as pumping continues.
5. Start pump, note time pumping began, and let pumping rate stabilize before checking flow rate with 5-gallon bucket.
6. Calculate pumping time required to purge desired volume (e.g., 30 gallons @ 5 gal/min = 6 minutes).
7. Sample well with a bailer after each purging (see "Monitoring Well Sampling with A Bailer" procedure).

**DOCUMENTATION:**

Record: 1) well number, 2) date, 3) priming water used (if any), 4) pumping rate, 5) minutes pumped, 6) volume discharged, 7) sampling method and 8) remarks on ground water sampling record form. Additional data and other forms may be necessary and should be specifically requested by the Project Manager.

**MONITORING WELL PURGING**  
**WITH A SUCTION (DITCH) PUMP**

**GOAL:**

Remove the required volume of water from a well to obtain a representative ground water sample while avoiding cross-contamination.

**TASK-SPECIFIC EQUIPMENT NEEDED:**

1. ditch pump with hoses
2. 5-gallon bucket
3. appropriate plumbing to fit desired well (packers)
4. water level tape
5. electrical tape

**PROCEDURE:**

1. Before each well is purged, the outside of the pump and any tubing that goes down the well will be washed with a lab grade soap, such as Alconox, and rinsed with distilled or deionized water. In addition, some water will be run through the pump to avoid cross-contamination.
2. Measure water level, confirm with second measurement. If water level is below approximately 22 feet, the ditch pump will probably not work. One casing volume (in gallons) is equal to  $3.14 r^2 h$  (7.48) where:  
  
v = volume in gallons  
"Pi" = 3.14  
r = radius of well in feet  
h = height of the water column in the well (refer to well casing volume calculation S.O.P.)
3. Assemble packer unit on well, ensuring a tight seal. Electrical tape may be necessary at the top of the well.
4. Attach hose from ditch pump inlet to packer unit. Position outlet hose from pump away from well.

5. If a drop pipe (or other conduit) is used, the lower end of the pipe should be maintained as close to the well water surface as practical.
6. Start pumping. Note time pumping began. Let pumping rate stabilize before checking flow rate with 5-gallon bucket.
7. Calculate pumping time required to purge desired volume.
8. Sample well with a bailer after purging (see "Monitoring Well Sampling with a Bailer" procedure).

**DOCUMENTATION:**

Record: 1) well number, 2) date, 3) priming water used (if any), 4) pumping rate, 5) minutes pumped, 6) volume discharged, 7) sampling method, and 8) remarks on ground water sampling field record form. Additional data and other forms may be necessary and should be specifically requested by the Project Manager.

# **STANDARD OPERATING PROCEDURE FOR FIELD DETERMINATION OF PH**

## **GROUND WATER, SURFACE WATER AND LEACHATE ANALYSIS**

### **1.0 Method Summary**

- 1.1 This is a determination of the activity of the hydrogen ions by potentiometric measurement.

### **2.0 Interferences**

- 2.1 Temperature is an important factor. The temperature compensator attached to the instrument automatically corrects the pH value displayed by the meter.

### **3.0 Instrumentation**

Beckman pH meter  
pH probe  
Automatic Temperature Compensator (ATC)

### **4.0 Materials and Reagents**

Sample cups  
Prepared pH 4 and 10 standards for calibration

### **5.0 Calibration**

During initial setup and calibration, two standards are run.

#### **Standardizing the Instrument**

- 5.1 Depress the CLEAR key to clear the instrument.
- 5.2 Rinse the electrode with distilled water and immerse in pH 4 buffer. Depress the STANDARD key. When the input from the electrode is stable, the instrument will automatically standardize on the pH value of 4.00 pH buffer. The STD1 symbol and the approximate value of the pH 4.00 buffer will appear in the DISPLAY.
- 5.3 Rinse the electrode with distilled water and immerse in pH 10 buffer. Depress the STANDARD key again. When the instrument stabilizes, the DISPLAY will include STD1, STD2, temperature, and the approximate value of the pH buffer 10.

- 5.4 The instrument is now ready to make a pH measurement. Rinse the electrode with distilled water and immerse in the sample.
- 5.5 Depress the pH key. Wait until the AUTO symbol flashes and then locks. The DISPLAY will indicate the measured temperature and pH.
- 5.6 This sequence can be repeated for additional pH measurements. Depress the pH key, wait for AUTO READ to lock, and note the pH value.
- 5.7 A  $\pm 0.05$  pH acceptance limit should be used in determining calibration acceptability. If unacceptable, recalibrate as described in 5.1.

## 6.0 Procedure

- 6.1 Prepare and analyze samples without delay.
- 6.2 Place about 50 mls of sample into a plastic cup and stir with the pH probe.
- 6.3 Allow the pH reading to stabilize. Collect three pH readings from each sample within  $\pm 0.5$  units. Record the pH values on the well or surface water sampling record form. Rinse the probe with distilled water and verify calibration by submersing in a prepared pH standard as described in 5.7.
- 6.4 Proceed to the next sample or location; verify calibration before each measurement.

## 7.0 Quality Control

- 7.1 Document all calibrations and verification readings, including time and meter readings.
- 7.2 Run duplicate measurements on each batch or every 10th sample.

## 8.0 Maintenance

- 8.1 Check battery (if used in field); and replace if discharged.
- 8.2 After use in samples containing free oil, wash the electrode in soap and rinse thoroughly with water. Immerse the lower third of the electrode in diluted HCL (1:9) solution for 10 minutes to remove any film formed. Rinse thoroughly with water.
- 8.3 Keep electrode properly filled with appropriate filling electrolyte solution.



# **STANDARD OPERATING PROCEDURE FOR FIELD DETERMINATION OF CONDUCTIVITY, METHOD 205**

## **GROUND WATER, SURFACE WATER AND WASTEWATER**

### **1.0 Method Summary**

- 1.1 Conductivity is a numerical expression on aqueous solution's ability to carry an electric current. This is dependent on the presence of ions, their concentrations, mobility, valence, and on the temperature of the solution.
- 1.2 The conductivity probe is immersed in a sample and the conductivity is read directly off of the meter scale.

### **2.0 Interferences**

- 2.1 Temperature greatly influences the electrolytic conductivity of a sample, therefore, it is extremely important accurate temperature measurements are made.

### **3.0 Instrumentation**

- 3.1 Conductance meter YSI Model 32.

### **4.0 Materials and Reagents**

Conductivity cell

Thermometer

Specimen containers

### **5.0 Standard**

- 5.1 Primary Working Standard:

Potassium chloride standard 0.01N: dissolved 0.7456 g anhydrous KCl in deionized water and dilute to 1 liter at 25°C. Conductivity = 1,413 umhos/cm.

### **6.0 Calibration**

- 6.1 Check the conductivity of the standard prior to actual sample evaluation. Record the temperature of each standard.
- 6.2 Calculate the conductivity at 25°C making adjustments for the temperature (see 8.1 for equation).

## 7.0 Procedure

- 7.1 Rinse the cell with deionized water.
- 7.2 Measure the conductivity of each sample by swirling the cell in a portion of the sample. Record the conductivity reading and the temperature. Collect three conductivity readings until the readings are within  $\pm 5$  umhos/cm.
- 7.3 Calculate the conductivity at 25°C as outlined in Section 8.1.

## 8.0 Calculations

8.1 Conductivity at 25°C = 
$$\frac{K}{1 + 0.0191(t-25)}$$

K = measured conductivity  
t - temperature of sample, °C

## 9.0 Quality Control

- 9.1 Document all calibrations and verification of readings including time and meter readings.
- 9.2 A blank of deionized water is run and should have a conductivity of less than 5 umhos/cm.
- 9.3 The initial standard is checked in between samples.
- 9.4 Duplicate measurements of conductivity will be taken at least once for every 10 investigative samples

# **STANDARD OPERATING PROCEDURE FOR FIELD DETERMINATION OXIDATION/REDUCTION POTENTIAL (Eh)**

## **GROUND WATER, SURFACE WATER AND LEACHATE ANALYSIS**

### **1.0 METHOD SUMMARY**

This is a measurement of the activity of the electrons in aqueous solution by potentiometric measurement. The Eh is read directly in millivolts (mV).

### **2.0 INSTRUMENTATION**

Beckman pH ion meter

Eh probe

### **3.0 MATERIALS AND REAGENTS**

Sample cups

Deionized water

Eh Standard Solutions

### **4.0 CALIBRATION**

Calibrate the instrument according to the instruction manual included with the instrument.

1. Depress the CLEAR key to clear the instrument.
2. Set scale to mV.
3. Rinse the electrode and immerse in deionized water. The instrument should read 0.0 mV.
4. The instrument is now ready to make a Eh measurement. Rinse the electrode with distilled water and immerse in the sample.
5. Depress the mV key. Wait until the AUTO symbol flashes and then locks. The DISPLAY will indicate the measured temperature and Eh.
6. This sequence can be repeated for additional Eh measurements. Depress the mV key, wait for AUTO READ to lock, and note the Eh and temperature values.

### **5.0 PROCEDURE**

1. Prepare and analyze samples without delay. Be careful not to aerate sample.
2. Place about 50 mls of sample into a plastic cup and stir slowly with the Eh probe.
3. Allow the Eh reading to stabilize. Collect three Eh readings from each sample and measure the temperature of the sample at the time each Eh reading is taken. Record the Eh and temperature values on the well or surface water sampling record form. Rinse the probe with distilled water and verify calibration by submersing in distilled water as described in 4.3.
4. Proceed to the next sample or location; verify calibration before each measurement.

## **6.0 QUALITY CONTROL**

1. Document all calibrations and verification readings, including time and meter readings.
2. Run duplicate measurements on each batch or every 10th sample.

## ELEVATION SURVEYS FOR MONITOR WELLS

### MINIMUM EQUIPMENT AND INFORMATION NEEDED

- standard surveyors level
- two persons
- well lock keys
- tools to open well caps
- survey forms
- tri-pod
- calculator
- stadia rod
- hand-held tape in 0.01-foot increments
- detailed well location map
- well numbers to be surveyed
- a point of known or relative elevation from which to begin survey

### JOB DESCRIPTION

Obtain survey elevations for wells.

### EXPECTATIONS

- Shoot and record well elevations at the *top of casing*.
- Shoot and record ground elevation at each well location.
- Tie all loops together and to reference datum.

The data generated from the survey is used to obtain accurate elevations which are necessary to gain a common reference point from which groundwater elevations, well screen elevations, cross-section maps, elevation contour maps, and more can be generated and compared to each other.

Before going into the field, decide with the person who has requested the work what the reference point should be. If the reference point is to be taken from a U.S.G.S. datum, it is necessary to know exactly where that benchmark is before beginning the survey. If a relative datum (e.g., 100.00 feet) is used, choose a benchmark that is a part of a permanent structure. Accurately detail the location chosen so that results may be duplicated in the future if necessary. An example of a good permanent benchmark may be a specific corner of a concrete foundation of a specific building, or a specific point on a fire hydrant.

The basic procedure is (refer to Example 1):

- A. Begin the survey by recording the elevation and location of the reference point.
- B. Set up the tri-pod and surveyor's level at the first station and level the instrument. Check instrument level by rotating 180°; relevel if necessary.

- C. Have one party hold the stadia rod on the reference point after the level and tri-pod have been set up.
- D. Record the elevation shot in the +S column. By adding the +S to the known elevation, the height of the instrument (HI) will be determined:  
$$\text{Elevation} + S = HI$$
- E. The rod man moves in the general direction of the well location and chooses a good turning point. The turning point must be well defined and solid, such as a rock, tree, root, or the top of a screw driver driven solidly into the ground.
- F. Record the reading at the turning point as a -S on the form. The -S reading is subtracted from the HI to give the elevation of the turning point:  
$$HI - S = \text{Elevation at Turning Point (TP - 1)}$$
- G. The instrument man now moves the tri-pod and level in the general direction of the well.
- H. The new reading is recorded as a +S.  
$$\text{Elevation at TP - 1} + S = \text{New HI}$$
- I. The procedure is repeated until a -S reading can be taken at each well top-of-casing and at each ground level at the well.
- J. It may be necessary to use several turning points and loops to obtain all the data required. Be sure they are all tied together.
- K. Once all the elevations have been recorded, close the loop. The rod man and instrument man proceed as before back to the original reference point. The loop is closed when the rod man returns to the original point of reference and that elevation is again recorded.
- L. Clean the well cap threads with a wire brush and lubricate with teflon paste or beeswax before replacing.
- M. Refer to the elevation survey illustration for a simple example.

## ACCURACY

Each elevation measurement must be recorded to the nearest 0.01 foot. An elevation survey is of acceptable accuracy if the beginning and final elevation are within  $\pm 0.03$  feet.

Check the work when the survey is complete. Make sure the locations of the benchmarks are described in detail. Describe any difficulties which may have had an effect on the data. Turn in the paperwork when it is completed and legible to the person who requested it. Keep records for personal files.

## HINTS

- If the rod cannot be positioned at the TOC, measure and record the elevation difference from TOC to the point where the rod was positioned.
- Rock the stadia rod toward and away from the instrument man at each location. The instrument man should record the lowest elevation reading as the rod is rocking. The lowest reading indicates when the rod is straight up and down.
- Use the top of casings (TOC's) as turning points. If this can be done, it will be possible to mathematically verify the results from the office.

## IMPORTANT TERMS

### ***BENCHMARK (BM):***

A definite point of known or assumed elevation not subject to change. Permanent benchmarks have been established throughout the United States by the U.S. Coast and Geodetic Survey and the U.S. Geologic Survey (U.S.G.S.). Benchmarks are used as starting points for surveys requiring a common reference point.

### ***SURVEY FIELD NOTES:***

The record of the work performed. Typical entries should be:

- date
- description of weather
- names of individuals in the party and their responsibilities
- the instrument and methods being used

### ***LEVEL NOTES:***

The standard form for recording stations and elevations taken (see example).

***PLUS SIGHT (+S):***

A rod reading taken on a point of known or assumed elevation. The plus sight added to the elevation at the point gives the height of the instrument.

***MINUS SIGHT (-S):***

A rod reading taken on a point where elevation is to be determined.  $HI - S =$  the elevation of the point.

***HEIGHT OF INSTRUMENT (HI):***

The elevation of the line of sight when the instrument is level.

***TURNING POINT (TP):***

A solid, well-defined point on which the rod is set while the instrument is being moved from one location to another. A minus sight is taken on a TP from the first level set-up to determine its elevation. A plus sight (+S) is taken on a TP from the second set-up to determine the new height of the instrument.

***TOP OF CASING (TOC):***

The top of casing or top of threads is the uppermost point of the well casing.



## **WATER LEVEL MEASUREMENT**

There are two devices that are acceptable for measuring water levels. These are a steel tape and water-soluble carpenter's chalk, and an electric tape. While the electric tape reports measurements to 0.01 foot, it is less accurate than the steel tape method; therefore, the steel tape method should be preferred over the electric tape.

For some applications, the electric tape is preferred. An electric tape gives an accurate measurement to the water without actually going into the water. The electric tape is less likely to cross contaminate between wells that are to be sampled. Since the electric tape only touches the water, it is easier to decontaminate after a water level measurement is taken. Water levels are obtained more quickly than with a steel tape.

The steel tape and chalk method is very accurate. This method, however, is a little less desirable for measuring water levels on wells that are to be sampled. The steel tape method introduces chalk to the water, the tape becomes rusted, and it is necessary to submerge a small portion of the tape to obtain a correct measurement.

The standard procedure for taking a water level measurement, whether using an electric tape or steel tape and chalk, is basically the same.

### **JOB DESCRIPTION:**

Obtain a round of water levels.

### **TASK-SPECIFIC EQUIPMENT AND MINIMUM INFORMATION NEEDED:**

- steel water level tape or electric water level indicator
- water-soluble carpenter's chalk
- paper towels
- hand-held engineer's measuring tape
- well location map
- well keys
- previous water level or water elevation data

### **EXPECTATIONS:**

Water levels will be taken at all the indicated wells and recorded to the nearest 0.01 foot.

Document the time, date, and the method of the measurement.

**PROCEDURES FOR A STEEL TAPE AND CHALK:**

1. Uncap all the wells of a cluster to be measured to allow the water levels to stabilize. Be sure to place the well caps on a clean area (use visqueen if necessary). Vented well caps should provide for minimum (essentially zero) time for water level stabilization.
2. Smear the graduated portion at the end of the tape with chalk.
3. Carefully lower the tape into the well until the chalked portion of the tape intersects the water in the well.
4. Advance the tape until the nearest one-foot increment of the tape is exactly even with the top-of-casing; record.
5. Recoil the tape from the well and read the water level measurement directly from the wetted portion of the tape; record.
6. Dry the tape with a paper towel and resmear it with chalk, and take a second, confirmation measurement; record.
7. Clean the tape before proceeding to the next well.
8. Replace the well cap.

**PROCEDURES FOR AN ELECTRIC WATER LEVEL INDICATOR:**

1. Uncap the wells.
2. Carefully lower the tape into the well.
3. The buzzer will sound as the probe hits the water. Once the buzzer has sounded, slowly pull the tape up until the buzzer turns off.
4. Read the measurement from the top-of-casing and record it.
5. Take a second measurement to confirm; record it.
6. Clean the tape before proceeding to the next well.
7. Replace the well cap.

Each time a water level measurement is taken, a second confirmation reading is necessary to ensure that the water level is stable. If the second measurement is within  $\pm 0.01$  feet of the first, the measurement is good and can be recorded as a stable water level. If the second measurement does not confirm the first, then wait for the well to stabilize and try again.

Indicate in your field notes if the measurements were taken after or during a period of rainfall. Be alert to any irregularities observed which may have an affect on the water levels (such as a nearby pumping well).

Always record the date, time and method of each measurement.

If the measurement references a "holding point" other than the top of the casing, or you are unsure of which point is the top of casing, indicate the reference point used, measure the difference between the top-of-casing and the reference point, and provide a diagram.

## WELL CASING VOLUME CALCULATION

Minimum information and equipment necessary to perform the task:

- well location map
- total depths of the wells
- water level tape
- calculator

Well casing volumes are important to determine the volume of water which must be purged from a well prior to collecting a groundwater sample which is representative of the screened aquifer. Obtaining this value is a two-step calculation:

$V = \pi r^2 H$  (7.48) is the equation for the volume of a cylinder and is used to make the volume calculation:

**ONE:**

where:

$V =$	volume of water in the casing (cubic feet)
" $\pi$ " =	3.14
$r =$	radius of well ( <i>feet</i> )
$H =$	height of the water column in the well (feet)
7.48 =	converts volume (V) from cubic feet to gallons

It is necessary to evacuate at least three volumes of water before sampling; therefore:

**TWO:**  $V \times 3 =$  volume of water to be purged prior to sampling

A simplified form of the equation for the volume of the cylinder is:

$$V = r^2 H (0.163)$$

where:

$V =$	volume of water in the casing (gallons)
$r =$	the inside radius of the well casing ( <i>inches</i> )
$H =$	the height of the water column in the well (feet)
	$H = H_o - H_1$
	$H_o =$ total length of the well measured from TOC
	$H_1 =$ the water level measured from TOC
0.163 =	a constant

Carefully avoid the possibility of cross-contamination between wells by rinsing water level tape off between wells.

## BOREHOLE GEOPHYSICAL LOGGING (GAMMA)

### OPERATING INSTRUCTIONS:

The Keck SR-3000 Logger can be used to measure the natural gamma emissions of a borehole. The unit is designed to detect the presence of gamma radiation emitted primarily from radioactive potassium (K40).

### INSTRUMENT DESCRIPTION:

The instrument is designed to be carried in a truck or large vehicle and is made up of three primary units: the cable reel, the control console, and the logging probe. The cable contains 1,500 feet of cable along with a 12-volt clutch-driven motor, depth indicator, and connector. The control console contains the logger speed, module select, recorder sensitivity, and power switches. Also, the console has two analog recorders with independent base line zero adjustments. Instrument modules are required for each logging tool and plug into the control console.

### INITIAL SET-UP PROCEDURE:

Connect the three interfacing cables between the control console and the cable reel. The cables should be connected as numbered on the units. Connect the two power cables to the control console and then connect the end clips to a 12-volt DC power supply making sure that the main power switch is off prior to the power hookup.

The next step is to position the system controls as follows (refer to Figure 1 for the system controls location):

<u>SWITCH</u>	<u>ITEM NO.</u>	<u>SETTING</u>
Main Power Switch	1	off
Logging Direction Switch	5	off
Speed Adjust Control	6	fully counter-clockwise
Zero Adjust	13 & 15	fully counter-clockwise
Module Selector Switches	7 & 8	off: center position
Recorder Sensitivity	9 & 10	1
Module Power Switches	20	off
Depth Counter	14	0000.0
Chart Speed	21	5

**GAMMA LOGGING SETUP:**

After the controls have been correctly positioned, the gamma logging module should be inserted into either one of the module slots, as shown in Figure 1. Next, the gamma ray sonde or logging tool should be connected to the cable reel connector. This may require reeling of some of the cable out of the cable reel. To do this, first turn on the main power switch, switch the logging direction switch to "down", and then slowly turn the speed adjust control knob. The vehicle should be turned on during logger operations. The connector and the tool should be mated by aligning the four pins, making sure that the larger pin is aligned with the larger hole. The connector is then slid together and the threaded cover should be screwed down securely.

The next step is to place the sonde in the borehole. The cable should be placed on the well cable pulley unit or a suitable substitute to prevent cable wear. Lower the cable until the connector (top of the sonde) is at ground surface.

At this point, the main power should be on and the gamma module is in one of the available slots. The instrument controls should be set as follows:

<u>SWITCH</u>	<u>ITEM NO.</u>	<u>SETTING</u>
Main Power Switch	1	on
Logging Direction Switch	5	off
Speed Adjust Control	6	fully counter-clockwise
Zero Adjust	13 & 15	fully counter-clockwise
Module Selector Switches	7 & 8	right or left
Recorder Sensitivity	9 & 10	1
Module Power Switches	20	on
Depth Counter	14	0000.0
Chart Speed	21	5

<u>MODULE ADJUSTMENTS</u>	<u>ITEM NO.</u>	<u>SETTING</u>
Module Power Switch	20	on
Time Constant	18	5
Sensitivity	17	1K

**ZEROING:**

First, make sure that both of the module selector switches are switched to the correct location, depending on which slot the gamma module has been inserted. Hold the zero button down with the pens in the "up" position and wait until the pen locations stabilize.

Then use of the zero adjust knobs (13 & 15) to position the pens at the left hand edge of the chart scale. At this point, it is a good idea to remove the pen covers.

### **DEPTH SETTING:**

Rotate the metal sheave on the cable unit by lifting and rotating until the depth indicator displays -1.9. This position corresponds to the depth of measurement of this sonde, assuming the top of the sonde is at ground surface. Now adjust the paper position until the pens are a depth of 1.9 feet (approximately two small squares).

### **LOGGING:**

Now lower the pens onto the paper; do not lower the pens to the lowest position, just lower them until they firmly contact the paper. Typical gamma reading for unconsolidated sediments ranges from 100 to 2000 counts per minute. Set the left channel sensitivity on 0.2 and the right channel sensitivity on 0.5. These two settings should be a good starting point, but if additional information on the geology is available, these starting positions can be varied.

Switch the logging direction switch to "down" and rotate the logging speed control knob until the cable speed indicator reads between 10 and 15 feet per minute.

The downhole log is typically used for adjustment, and sensitivities and time constant can be varied until a satisfactory log is being generated. Continue logging until the bottom of the boring is encountered. At this point, switch the logging direction switch to the "middle" position and rotate the speed control fully counter-clockwise. Lift the pens off the paper. Now remove the cable slack. The depth reading should correspond closely to the depth of the boring. Rotate the paper in each of the recorders until the lines line up on the footage corresponding to that on the depth indicator. Lower the pens. Switch the logging direction switch to the "up" position and rotate the logging speed control until the logging speed reads at or below 10 feet per minute. Maintain the logging speed as close to a constant speed as possible. Continue logging until the sonde reaches the starting position. The pens should be at or near the zero depth position on the chart paper.

Remove the chart paper and record the instrument settings, logging speed, depths, date, well number, operator, job number, and client in pencil on the log.

### **INSTRUMENT CALIBRATION:**

Field calibration of the gamma ray sonde is not necessary. The instrument is calibrated during manufacturing and must be periodically checked by the manufacturer.

**BOREHOLE GEOPHYSICAL LOGGING (EM INDUCTION)****OPERATING INSTRUCTIONS:**

Electromagnetic induction logging is done using the Geonics EM39 borehole logger. The probe, which can be deployed in plastic cased or uncased wells, measures the electrical conductivity of surrounding soil or rock (saturated or unsaturated) within a zone of 8 to 40 inches from the well axis. In saturated conditions, measurements are dominated by the conductivity of the water in surrounding soil and rock. The EM39 probe is insensitive to the conductivity of the borehole fluid.

**INSTRUMENT DESCRIPTION:**

The EM39 logging unit portable and is made up of four primary units: the cable reel (winch), the control console, the logging probe and a recorder unit. The cable reel is hand driven and contains 325 feet of cable along with a connector. The control console contains the depth display, sensitivity switch, in-phase and quadrature compensation switches and power switches. Output from the console is analog and consists of 300 mV signal per full scale deflection for the conductivity component and 100 mV signal per full scale deflection for the inphase component. These output signals are suitable for input to either a strip chart recorder or an Omnidata Polycorder. The EM39 instrument probe consists of a self-contained dipole transmitter/receiver with a 50 cm coil separation. Either an external 12-volt battery or an internal battery system can be used to operate the unit.

**INITIAL SET-UP PROCEDURE:**

Connect the interfacing cable between the control console and the cable reel. Connect the interfacing cable from the control console to the recorder. Connect the probe connector to the cablehead connector. Make sure that the pins on the probe connector are straight and apply silicone lubricant to the rubber portion of the probe connector. Align the connectors and tighten the cablehead nut. If an external power source is to be used, connect the power cable to the control console and then connect the end clips to a 12-volt DC power supply making sure that the main power switch is off prior to the power hookup.

Before operating using the internal battery, check the battery condition: set the sensitivity switch to the "BATT" positions (one negative and one positive) and check the meter display. If either is low, replace the batteries or check that the contacts are clean. When using an external battery, the meter reading should deflect 80% of full scale on the battery test.



To NULL the instrument, carry the probe to an area free of metal objects. Lift the instrument probe to a level of 5 feet off the ground. Set the range switch to 3000 mmhos/m and adjust the "Q/P" control until the needle reads zero. Repeat on each sensitivity setting. On the most sensitive scale, push the "I/P" switch and adjust the "I/P" zero control to set the meter to zero. Recheck the "Q/P" reading for zero. The instrument is now ready for logging.

### **INDUCTION LOGGING SETUP:**

Measure the well stickup using a tape measure (for wells with above ground level protective casing). Place a piece of duct tape on the instrument probe, at a distance equal to the well stickup, above the probe zero (yellow tape). Place the instrument probe in the borehole. The cable should be placed on the well cable pulley unit to prevent cable wear. Lower the cable until the zero point of the probe is at the ground surface (for wells with stickup, until the duct tape is even with the top of protective casing).

At this point, press the depth counter button to reset the depth to zero. If a strip chart recorder is being used, select an appropriate range scale. Activate both recorder channels. Position the recorder monitor switches for each channel to "zero check" and move the pens to their respective zero positions on the strip chart paper. Raise the pens and position the recorder monitor switches to "measure".

### **INDUCTION LOGGING:**

The downhole log is typically used for adjustment, and sensitivities can be varied until a satisfactory log is being generated. Turn the cable winch to slowly lower the instrument probe to the bottom of the well/borehole. The depth reading should correspond closely to the depth of the boring. At this point, if a strip chart recorder is being used, lower the recorder pens on the strip chart recorder and switch the chart drive to "EXT". If a polycorder is being used, execute the logging program and set up the logging parameters. Rotate the winch to raise the instrument probe steadily at a speed of not more than 10 feet per minute. Continue logging until the instrument probe zero mark is even with the ground surface, or in the case of well stickup, the duct tape mark is even with the top-of-protective casing.

If using a strip chart recorder, remove the chart paper and record the instrument settings, logging speed, depths, date, well number, operator, job number, and client in pencil on the log.

### **INSTRUMENT CALIBRATION:**

The instrument is calibrated during manufacturing and must be periodically checked by the manufacturer.

## **SLUG TESTS**

### **JOB DESCRIPTION:**

In-situ hydraulic conductivity tests or slug tests, are single-well aquifer tests in which a known quantity of water is instantaneously injected or removed from a well. The test is performed to help determine the permeability characteristics of the aquifer at the screened interval.

EDI has found that a procedure which utilizes the application of a vacuum to draw water into a well is very efficient. This procedure is described here. Refer to the owners manual for the Hermit throughout the test.

### **TASK SPECIFIC EQUIPMENT AND MINIMUM INFORMATION NEEDED:**

Hermit data logger  
10 psi pressure transducer  
Adaptor cable from Hermit to transducer  
Pressure/Vacuum pump (Air Cadet)  
Valves, pipe fittings, etc., for the well head  
Teflon tape  
Water level tape  
12 volt battery (remote or use automobile battery)  
Well construction information (well logs) and well diameters  
Hermit owners manual  
Jumper cables  
Well screens must be completely submerged in order to perform test

### **EXPECTATIONS**

Record water level data.  
Record initial settings of the Hermit parameters.  
Field check the data.

### **PROCEDURE:**

1. Measure and record static water level.
2. Record well number, date, time, water level, overall well depth, test number and step number of Hermit.
3. Attach the test fittings to the well head. Use the teflon tape to assure an air-tight seal.

4. Position the transducer 5 feet below static water level (15 to 17 feet if pressure is to be applied to the well). Exact depth of the transducer can be determined using the Hermit prior to making the initial test settings and after the cables have been connected.
5. Connect the cables between the Hermit and the transducer.
6. Install the rubber fittings around the transducer cable to insure an air-tight connection.
7. Connect clear tubing between the pressure/vacuum pump and well head fitting.
8. Reference Hermit to zero. Record the initial transducer value.
9. Close the large valve on the well head apparatus, and open the small valve to the pump.
10. Connect wires from pump to 12-volt power supply.
11. Allow pressure/vacuum to stabilize within the well. The well is stable when the transducer value remains fairly constant for 25 to 30 seconds. This value should, in theory, equal the initial transducer value.
12. Close the small valve to the pump.
13. Immediately after closing the valve, start the Hermit.
14. When the test has begun, the Hermit will display "Log 1". As soon as this is displayed, open the large valve.
15. Turn the pump off.
16. Allow the water level to return to the initial static water level. The water levels can only be displayed after the first 10 minutes of the test.
17. Once the water level restabilizes, stop the test and remove all apparatus removed from the well.
18. Field check the data.

The Hermit is designed to run up to 10 slug tests. However, up to 50 tests can be run with one Hermit by stepping the tests. Stepping should, as a rule, be avoided while

running slug tests as there is a greater chance for losing data due to operator error. Refer to the Hermit owner's manual for the stepping procedure.

If the static water level is within 5 feet of the top of casing, it is recommended that a pressure rather than a vacuum be applied. This is done to avoid pulling the water up into the pump.

Try to achieve 3 to 5 feet of water level change at the start of the test.

If the ambient temperature is greatly different than the ground water temperature (above 80°F or below 30°F), allow about 10 minutes for the transducer to stabilize before initiating the test.

## SURFACE WATER FLOW MEASUREMENTS

### JOB DESCRIPTION:

To obtain an accurate measurement of surface water flow.

### EQUIPMENT NEEDED:

- surface water velocity meter
- measuring tape with weighted end
- metal adjustable rods

### PROCEDURE:

1. Locate site where flow is to be measured and set up measurement grid. Distance between each location should be constant; 2-foot or 5-foot intervals are recommended.
2. Measure the distance to the bottom of the water column at each grid and record.
3. Measure the distance to the top of the water at each grid and record.
4. Subtract the two to determine the height of the water column.

a = distance to bottom of body of water \_\_\_\_\_  
b = distance to top of water \_\_\_\_\_  
c = height of water column (b - a) \_\_\_\_\_

If c is between 0.3 feet and 2.50 feet, then measure the velocity at six-tenths of c; e.g.:

a = 12.00 feet  
b = 10.20 feet  
c = 1.80 feet

Multiply 1.80 feet by 0.6 to obtain the depth where the velocity is to be measured, in this case at 1.08 feet below the top of the water column.

If c is greater than 2.50 feet, use the two-point method. With the two-point method velocity measurements are taken at two-tenths and eight-tenths of c and then are averaged, e.g.:

a = 12.00 feet  
b = 6.00 feet  
c = 6.00 feet

Multiply 6.00 feet by 0.2 to obtain 1.2 feet below the water surface. Also, multiply 6.00 feet by 0.8 to obtain 4.8 feet below the water surface. Measure the flow at the two determined depths, 1.2 feet and 4.8 feet. Average the results of both depths to determine the flow for this location.

5. Calculate the flow. Flow equals velocity (ft/sec) times cross sectional area (ft<sup>2</sup>). The cross sectional area for each velocity measurement is the average depth of water at each place where velocity is measured times the distance between each measurement. The total flow is the sum of the velocity times the cross sectional area for each velocity measurement.

$$\text{Flow} = \sum_{i=1}^n (V_i \times A_i)$$

where:  $V_i$  = velocity of measuring point  $i$  (ft/sec)  
 $A_i$  = cross sectional area at measuring point  $i$  (ft<sup>2</sup>)

## NUMERICAL GROUND WATER FLOW MODELING

### INTRODUCTION

Simulation of a ground water system refers to the construction and operation of a mathematical model that mimics the hydraulic behavior of an aquifer system. While the model itself obviously lacks the detailed reality of the ground water system, the behavior of a valid model approximates that of the aquifer. These approximations of ground water systems are useful tools for evaluating and testing a variety of hydrogeologic concepts. The various applications of ground water models are shown in Figure 1.

### MODEL USE

The first step in applying a ground water model is to determine if a modeling approach is necessary to meet the stated objects. If the modeling approach is selected, the next step is to select the appropriate model which can meet the objectives. In general, analytical models should be used for areas with simple hydrogeology or where the disparity of data and level of accuracy does not warrant the use of a more complex model. More complex numerical models such as the finite difference and finite element methods should be applied in lieu of analytical models in areas of complex hydrogeology when the assumptions forced on analytical models do not apply. The decision as to which type of numerical model to apply should be based on the advantages and drawbacks of each model type. The reader is referred to Mercer and Faust (1981) for a description of the various numerical models and their application.

The application of a ground water model will usually consist of 4 main tasks: setup, calibration, sensitivity analysis and simulation of the hydrogeologic system. Additional tasks may be added depending on the different requirements of each model application. These tasks should not be considered separate steps of a chronological procedure: rather, they should be considered as a iterative feed-back approach as shown in Figure 2.

### MODEL LOG

Prior to initiating the actual input of the data into the ground water flow model, a model log should be setup with an appropriate format to enable the documentation modeling process. The purpose of the model log is to document the modeling assumptions and procedures to provide a formal method for Quality Assurance and Quality Control (QA/QC). The organization and format of the model log should include a section for each main task (i.e., setup, calibration, etc.) organized by the order of completion. Since

ground water modeling is an iterative approach the different sections may be repeated in the model log (i.e.. the model was recalibrated to newly collected data). An example model log entry form is provided in Figure 3 illustrating the information to be recorded for each model run. The inclusion of information in the form of tables and figures to document the modeling is strongly recommended whenever possible.

## MODEL SETUP

The setup section of the model log will include as a minimum information regarding the following aspects of model setup and their relationship to the site's hydrogeology.

1. A brief description of the hydrogeology of the site.
2. Aspects of the grid construction including a description and rationale for the following:
  - node spacing;
  - assignment of model layers to aquifer units;
  - simulation of boundary conditions; and
  - assignment of initial input parameters.
3. Support software used to manipulate and input data.
4. A tentative file naming protocol for each of the model task which generates significant output as well as identification for the location of backup file copies.

The setup portion of the ground water modeling tasks can be broken down into three steps. The first step is to construct a grid or mesh over the area of investigation to serve as a base for inputting the site data. When constructing a finite difference grid the following guidelines should be followed:

1. The grid or mesh boundaries should be extended a sufficient distance away from the area of interest (i.e. simulated stresses) to eliminate their influence. Whenever possible, the boundaries should be extended to coincide with naturally occurring boundary conditions.



2. The node spacing should be sufficiently dense to capture the aspects of the ground water flow system without becoming too dense and causing excessive model run times.
3. For variable spaced nodes, the increase in node spacing and/or cell thickness should not exceed two times the node spacing and/or cell thickness of adjacent nodes.

The second step consists of conforming the site data to the format required by the specific model. Whenever possible, interactive graphical methods will be utilized to manipulate data. Graphical techniques are superior to other preprocessing styles because perception and comprehension of visual images are much faster and more accurate than comprehension of alphanumeric formats.

The third step consists of series of trial model runs to remove input errors and tune the model convergence. Upon completion of a model run which is moderately representative but not fully calibrated, the initial input data will be submitted for a QA/QC review.

## CALIBRATION

Following completion of the setup task, input variables for the model will be adjusted until a reasonable match between the model results and the set of calibration data are obtained. When possible it is strongly recommended that the ground water flow model be calibrated to as many sets of data as reasonably possible. Data selected for use in calibrating the model will be documented in the calibration section of the model log. The following list is an example of some of the data which might be used to calibrate the ground water flow model:

- ground water elevations;
- pump test data;
- boundary discharge/recharge rates;
- vertical head gradients;
- hydraulic conductivity distributions; and
- storage coefficient distributions.

Documentation regarding each calibration run will be recorded in the calibration section of the model log. The documentation will include as a minimum the parameter adjusted, quantification of the degree of calibration (tables of the actual values versus modeled values for select variables), and sufficient information to identify the calibration run and retrieve the pertinent files at a later date. Statistical analysis to determine the degree of calibration is used when possible.

After completion of the model calibration, information regarding the degree of calibration will be compiled as a closing for the calibration section of the model log. The closing will include information either in table or graphical form showing actual versus modeled values for each set of data used to calibrate the model. Additional comments addressing discrepancies between the actual and modeled values will also be included.

## **SIMULATIONS**

The simulation portion of the modeling effort will be strongly influenced by the particular objectives of each project. Typically it will consist of a set of scenarios to evaluate a remedial concept or determine hydrogeologic parameters for design considerations. Regardless of the application, documentation of the simulations should be maintained in the model log in a similar manner as the previous sections.

## **SENSITIVITY ANALYSIS**

Due to the fact that data for portions of the model grid or mesh data will be unavailable or of limited accuracy, and that for these areas input variables will have to be interpolated or estimated, a sensitivity analysis will be conducted on the model. The purpose of the sensitivity analysis will be to assess the need for collecting additional data based on the impact of the estimated values on the model results. The sensitivity analysis will be conducted by varying each of the relevant input parameters through the maximum and minimum values expected to be encountered at the site while holding the remaining variables constant. The results of the sensitivity analysis will be used to identify critical variables. The following list is an example of some of the data which might be used to conduct a sensitivity analysis of the model:

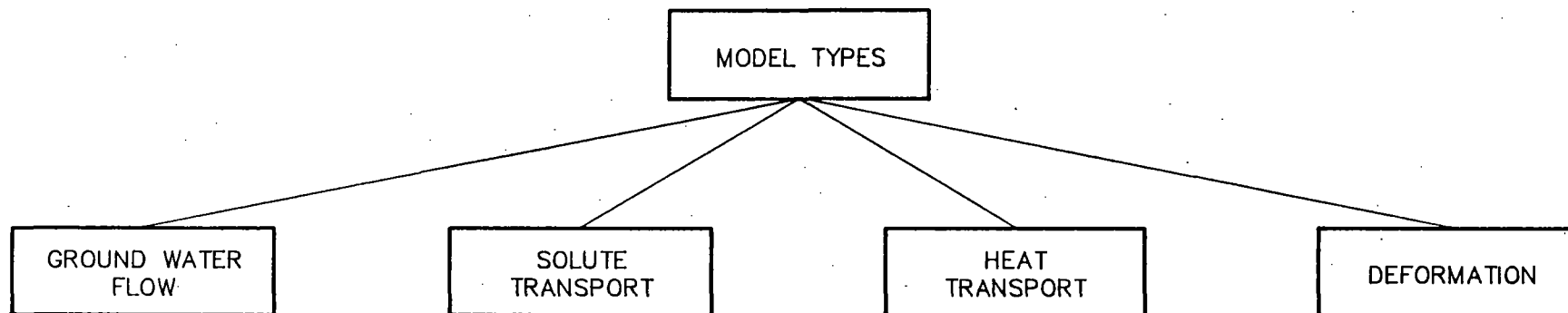
- hydraulic conductivity distributions;
- storage coefficient distributions;

- boundary discharge/recharge rates;
- variations in the regional ground water flow direction;
- dispersion coefficients; and
- retardation factors.

Information regarding the degree of sensitivity will be compiled as a closing for the sensitivity section of the model log. The closing will include information either in table or graphical form showing the results for each variable evaluated. Additional comments addressing the detailed aspects of variables which potentially impact the model prediction or results should also be included.

## **REFERENCES**

MERCER, J. W., and C. R. FAUST, *Ground-Water Modeling*. Dublin, Ohio: National Water Well Association, 1981, 60 pp.



### APPLICATIONS

- |   |                               |                     |                   |
|---|-------------------------------|---------------------|-------------------|
| – WATER SUPPLY                            | – PLUME MIGRATION AND CAPTURE | – GEOTHERMAL        | – LAND SUBSIDENCE |
| – REGIONAL AQUIFER ANALYSIS               | – SEA-WATER INTRUSION         | – THERMAL STORAGE   |                   |
| – NEAR-WELL PERFORMANCE                   | – LANDFILLS                   | – HEAT PUMP         |                   |
| – GROUND WATER/SURFACE WATER INTERACTIONS | – WASTE INJECTION             | – THERMAL POLLUTION |                   |
| – DEWATERING OPERATIONS                   | – RADIOACTIVE WASTE STORAGE   |                     |                   |
|   | – HOLDING PONDS               |                     |                   |

04011SNA  
LVP021392

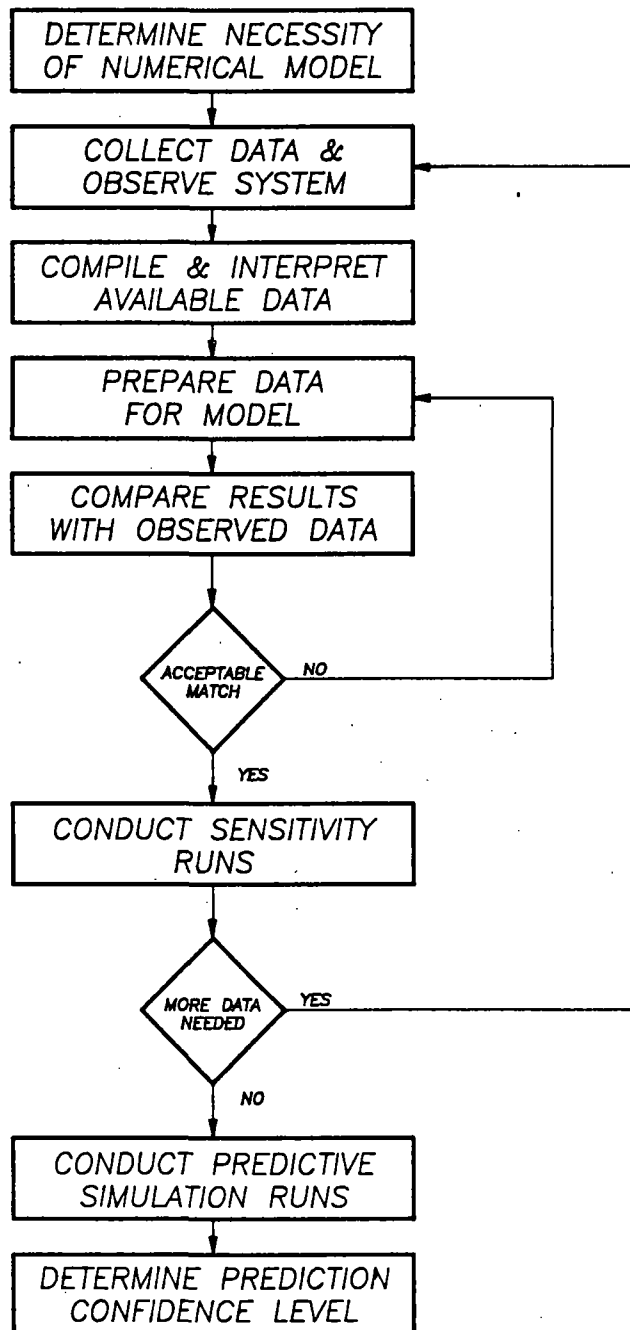
FIGURE 1

## SCHEMATIC OF NUMERICAL APPLICATIONS

ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

FEBRUARY, 1992

04011



MODSOP  
VR021492

FIGURE 2  
**NUMERICAL MODELING  
FLOW CHART**

ALBION-SHERIDAN TOWNSHIP LANDFILL  
ALBION, MICHIGAN

FEBRUARY, 1992

04011

FIGURE 3

Project Name:			Project #:	
Run #:	Date:	Time:	Model	Time Disc.
Initial Setup	Calibration	Sensitivity	Verification	
Purge Scenario	Water Res. Invest.	Particle Tracking		

Objective

File Information
Output File Name:
Grid File Name
Input File Edited:
Input File Edited:
Input File Edited:
Other:

[illegible][illegible][illegible]

## **TEMPORARY WELLS THROUGH HOLLOW-STEM AUGERS**

Temporary wells are used to obtain a representative ground water sample from a discreet depth when permanent well construction is not desired.

### **PROCEDURE:**

1. Advance the augers to the depth for the bottom of the well screen.
2. Remove the drill plug.
3. Lower the steam-cleaned well assembly to the bottom of the borehole.
4. If necessary, sand pack the well screen with clean, coarse sand grade silica sand to 1 foot above the top of the screen. Retract the augers while adding the sandpack.
5. Develop the well until sediment-free water is produced or at least three casing volumes are removed.
6. Sample the well with a clean bailer.
7. Pull the well out of the borehole.
8. Follow standard procedures for grouting the borehole.

## **STANDARD OPERATING PROCEDURE**

### **Field Analyses For Volatile Organic Compounds In Ground Water Samples**

#### **Method Description:**

Samples of ground water collected in 40ml VOA vials will be analyzed in a temporary field laboratory at the Albion-Sheridan Township Landfill site for the compounds identified in Table A-1. The samples will be analyzed using a heated headspace technique. Samples will be collected with zero headspace and then 30ml of sample will be transferred to a second 40ml vial for the purpose of headspace analysis. A gas chromatograph with a photoionization detector will be employed for the analyses. Quality assurance objectives for these analyses are given in Table A-2.

#### **Instrumentation and Equipment**

1. Hewlett Packard 5890A GC or equivalent equipped with HNU Model PI-52-02A photoionization detector. Lamp 11.7 ev.
2. Hewlett Packard Model 3392A Integrator.
3. 8-foot SS column. 1/8" OD, packed with 1% SP1000 on 60/80 Carbopack B.
4. Standard materials.
5. Gas tight syringes: 5 ml, 1 ml, 100 ul.
6. Hamilton syringes: 500 ul, 10 ul.
7. 40 ml VOA vials

#### **Standard Preparation**

- A. Stock standards consisting of the chemicals listed in Table A-1 will be purchased from a commercial supplier.
- B. An intermediate standard of approximately 1 part per million PPM will be prepared by diluting the commercial standard. The exact dilution required and the exact concentration of each component of the intermediate will depend on the concentration of each component in the stock standard.
- C. A series of working standards will be prepared from the intermediate. The concentrations of the working standards will be approximately 10 parts per billion (PPB), 100 PPB, and 1,000 PPB. The exact concentration of each component



again will depend on the exact concentrations supplied in the stock standard. The working standards will be prepared in 40 ml vials using 30ml of distilled DI water that has been bubbled with nitrogen. Each working standard will be agitated by hand for exactly 30 seconds and then will be heated in an 80°C water bath for exactly 15 minutes.

All standards prepared will be recorded in the standards log book. Intermediate and working standards are to be prepared on a daily basis.

#### Analysis:

##### A. GC Conditions:

1. Injector and detector temperature 210°C.
2. Column program - 50°C for 1 minute then programmed to 210°C at 10°C/min.
3. Detector - 11.7 ev photoionization.
4. Carrier gas - nitrogen (flow rate 30 ml/min).
5. Attenuation as necessary.
6. Injection volume - 1 cc.

##### B. Initial Calibration:

The external standard calibration method will be used for this analysis. Inject the working standards by withdrawing 1 cc from the headspace of the vial and injecting onto the GC column. Calculate calibration factors for each compound using the following formula:  $CF = \text{peak area/compound amount (ppb)}$ . Calculate the % RSD for each compound. If the % RSD is  $\leq 25$ , linearity through the origin is assumed and the average CF can be used for calculations. If the % RSD is  $> 25\%$  then re-analyze the three point calibration curve. If reanalysis does not lower the % RSD to  $\leq 25\%$ , then calculations should be based on ratioing the compound against the closest calibration standard. The three point curve will be verified by the analysis of a calibration check standard. This standard will be prepared so as to be equivalent in concentration to working standard #2. Acceptance criteria for this standard is found in Table A-2 under Continuing Calibration.

The RSD is calculated as follows:

$$\% \text{ RSD} = \frac{S(CF1, CF2, CF3)}{\frac{CF1 + CF2 + CF3}{3}} \times 100$$

where S = standard deviation

### C. Sample Analysis:

Samples will be collected in 40ml VOA vials and brought to the field laboratory. The samples will be analyzed no later than 12 hours after collection. Typically samples will be analyzed between thirty minutes and two hours after collection. Withdraw 1 cc of sample through the septum using a gas tight syringe. Inject sample onto the GC in the same manner as the standards were injected.

### D. Continuing Calibration:

Calibration should be checked on a regular basis to ensure data quality. After ten samples have been analyzed, re-inject working standard #2. Determine the percent difference (% D) for each compound.

$$\% D = \frac{CF(new) - CF(curve)}{CF(Curve)} \times 100$$

The % D must be  $\pm 20\%$  of the initial calibration curve. If a compound fails this criteria, re-inject the standard and recalculate the % D. If the compound fails again, a new 3-point calibration curve must be constructed. Samples analyzed prior to this continuing calibration should be re-analyzed if they contain the compound which failed this QC requirement.

Each morning in which analyses are to be run, inject 1 cc of working standard #2. If the % D for each compound is  $\leq 20\%$  of the initial 3-point calibration, analyses may begin. If not, reconstruct a new 3-point calibration curve. Also analyze the calibration check standard. If the % D for each compound is  $\leq 20\%$  of the initial 3-point curve, analyses may begin. If not, reconstruct a new working curve.

### Quality Assurance/Quality Control

In order to verify data quality, duplicate analysis and matrix spike data will be generated after every ten samples. If these quality control samples do not meet the acceptance criteria outlined in Table A-2, the system is out of control and corrective action will be initiated. Initially the GC will be checked for problems. If no problems are found, the QC sample which failed will be re-injected. If the problem persists, a new calibration curve will be constructed and the prior group of ten samples will be re-analyzed if necessary.

Additional QC will involve the demonstration of non-detectable contaminants of interest in field equipment blanks. Field equipment blanks will be analyzed after every ten samples. Trip blanks will follow samples from the field to the laboratory and will be analyzed as necessary. Positive field blank data will be reviewed by the laboratory chemist and best professional judgement will be used should the decision involve potential resampling of that days samples.

All quality control results will be recorded in the GC log book. Example calibration and data sheets are provided at the end of this SOP. Any corrective actions or routine maintenance performed on the GC will be recorded in the GC maintenance log.

### **Data Deliverables**

Data deliverables for this project will include the following:

- a. Case narrative describing the method of analysis, problems encountered and corrective action.
- b. Summary of calibration data (initial and continuing).
- c. Summary of sample data by number.
- d. Summary of QA/QC data (blanks, duplicates).
- e. Raw data including chromatograms and calculations.
- f. Instrument and standards log book detailing entries for the project.

### **References**

1. U.S. EPA 1986. Test Methods For Evaluating Solid Waste: Method 3810 - Headspace. Method 8000 - Gas Chromatography. SW846, Third Edition, Volume 1B: Laboratory Manual, Physical/Chemical Methods.
2. GC Operation and Calibration Procedures
  - A. Hewlett Packard 5890A and 3392A. All operation, calibration and maintenance procedures for the Hewlett Packard GC will be in accordance with the factory reference manual, Volumes I and II, and subsequent revisions. All operation and maintenance procedures for the HP 3392A integrator will be in accordance with the factory reference manual (June 1984 and any subsequent revisions).
  - B. Photoionization Detector.  
All operation and maintenance procedures for the HNU Model PI-52-02 A photoionization detector will be in accordance with the factory reference manual.

**TABLE A-1**

**LIST OF VOLATILE ORGANIC COMPOUNDS  
FOR FIELD ANALYSIS OF GROUND WATER  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

<u>Compound</u>	<u>Ground Water Detection Limit (ppb)</u>
Benzene	1-10
Bromodichloromethane	1-10
Bromoform	1-10
Bromomethane	1-10
Carbon Tetrachloride	1-10
Chlorobenzene	1-10
Chloroethane	1-10
2-Chloroethylvinyl ether	1-10
Chloroform	1-10
Chloromethane	1-10
Dibromochloromethane	1-10
Dichlorodifluoromethane	1-10
1,1-Dichloroethane	1-10
1,2-Dichloroethane	1-10
1,1-Dichloroethylene	1-10
Trans-1,2-Dichloroethylene	1-10
1,2-Dichloropropane	1-10
Cis-1,3-Dichloropropylene	1-10
Trans-1,3-Dichloropropylene	1-10
Ethyl benzene	1-10
Methylene chloride	1-10
1,1,2,2-tetrachloroethane	1-10
Tetrachloroethylene	1-10
Toluene	1-10
1,1,1-Trichloroethane	1-10
1,1,2-Trichloroethane	1-10
Trichloroethylene	1-10
Trichlorofluoromethane	1-10
Vinyl chloride	1-10

**TABLE A-2**

**QUALITY ASSURANCE OBJECTIVES FOR ANALYSIS OF  
VOLATILE ORGANIC COMPOUNDS IN GROUND WATER**

<u>Compound</u>	<u>Calibration Range (ppb)</u>	<u>Detection Limit (ppb)</u>	<u>Initial Calibration Criteria % RSD</u>	<u>Precision % RD</u>	<u>Matrix Spike % D</u>	<u>% Completeness</u>
All Compounds listed in Table A-1	10 - 1,000 (approx.)	10	≤ 25	± 20	± 30	90

## HEWLETT PACKARD GC CALIBRATION SHEETS

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Sample ID#: \_\_\_\_\_

Location and depth of sample:

\_\_\_\_\_

Description of location:

\_\_\_\_\_

\_\_\_\_\_

Attach strip chart:

Summary of tentatively identified compounds:

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

Others: \_\_\_\_\_

Attach calculations:

## HEWLETT PACKARD GC CALIBRATION SHEETS

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Summarize the types and concentrations of standards:

---

---

---

---

---

---

Attach strip chart:

Calculate peak values (attach calculations):

## **SURFACE WATER SAMPLING**

### **JOB DESCRIPTION:**

Collect surface water samples.

### **EQUIPMENT NEEDED:**

- Detailed map of sampling locations
- Sample bottles
- Gloves
- Waders or boat, if necessary
- Life preservers for deep water or swift current
- Safety rope
- Bailer or Van Dorn sampler
- Messenger (Van Dorn sampler only)

### **EXPECTATIONS:**

Samples will be collected properly. Sample locations will be identified on a map or an aerial photograph.

### **PROCEDURES:**

1. Begin sampling at the most downstream location and work upstream. Collect water samples before sediment samples (if any).
2. Note your location with reference to one or more mapped or photo-identifiable features (bridge, solitary tree, building, other distinct structure), or by upstream distance from a previous station. Mark your location on a map or aerial photograph.
3. Position yourself so that you are facing into the flow. If you are in the water, stand downstream of the sampler or sample bottle so that water flows into the sampler or sample bottle before it flows past you. The right bank is the side to your right when looking upstream.
4. Note flow (smooth, turbulent, or measure), water depth, stream width, and weather. Note any significant features at or beyond the water's edge such as a gravel bank, large fallen tree, boulder, utility marker, property sign, or high water mark.
5. Use the Van Dorn sampler for deeper water. Use the vertical Van Dorn for still water and the horizontal Van Dorn for flowing water. Use a bailer or collect the sample directly into the sample bottle for shallow water samples.
6. Number the sample positions in a cross-section beginning from the right bank and proceeding across to the left bank.



## **FIELD DETERMINATION OF DISSOLVED OXYGEN FOR GROUND WATER, SURFACE WATER, AND WASTEWATER**

### **1.0 METHOD SUMMARY**

- 1.1 Oxygen pressure on a permeable membrane causes oxygen to pass through and react with a cathode, causing a current to flow. Therefore, the oxygen pressure is directly proportional to the current and measuring the current is a measure of dissolved oxygen in the solution. Percent oxygen saturation is a function of the oxygen concentration and temperature. The YSI Dissolved Oxygen meter measures dissolved oxygen, percent oxygen saturation, and temperature.

### **2.0 INTERFERENCES**

- 2.1 Temperature is important and is compensated for by the temperature measuring device attached to the instrument.
- 2.2 Atmospheric pressure is also important and needs to be calibrated before taking measurements.
- 2.3 Salinity affects the readings and needs to be compensated for. The salinity correction is usually not important in fresh water.

### **3.0 INSTRUMENTATION**

YSI Model 58 Meter  
YSI Model 5739 Probe  
Lead 5740 Cable at desired length  
Calibration Chamber (Plastic Bottle)

### **4.0 MATERIALS AND REAGENTS**

Permeable Membrane  
Specimen Containers, if needed  
Electrolyte Solution (KC)  
Batteries (4 D size)

### **5.0 PROBE PREPARATION**

- 5.1 After removing the membrane and O-ring, thoroughly rinse the probe with electrolyte solution (KCl).
- 5.2 Fill the probe with electrolyte while alternately pumping the diaphragm on the side with a blunt object, such as the eraser end of a pencil until the probe is completely full and no more bubbles appear.

- 5.3 Secure one end of the membrane with the thumb of the same hand holding the probe. Then, using the other hand, stretch the membrane up, over and down the side of the sensor. Be sure not to trap any air bubbles underneath.
- 5.4 Secure the membrane on the other side of the probe and make sure there is a tight fit.
- 5.5 Replace the O-ring, leaving no wrinkles in the membrane, and cut off the excess membrane. Be sure that the stainless steel temperature sensor is not covered by excess membrane. Then replace the sensor guard.
- 5.6 The membrane selector switch inside the instrument case must be set to the position corresponding to the membrane in use.

## 6.0 CALIBRATION

Daily calibration is generally appropriate. Calibration can be disturbed by a physical shock, touching the membrane, fouling of the membrane, or drying out of the electrolyte. Check the calibration after each series of measurements and recalibrate as necessary. Air calibration procedure is as follows:

- 6.1 You must know the barometric pressure or the altitude at the site in order to perform calibration.
- 6.2 Turn the unit on with the probe connected about 15 minutes before starting calibration.
- 6.3 Using the % mode, place the probe in a 100% humidity environment, such as the calibration chamber with a moist towel, where temperature will be constant (insulate if needed) and as close to the sample temperature as possible.
- 6.4 Set the function switch to ZERO and adjust the display to read 0.00, then switch back to % mode.
- 6.5 When the display is stabilized, unlock the O<sub>2</sub> CALIB lock ring and adjust the display according to the pressure/altitude chart on the back of the unit. Then relock the lock ring to prevent calibration changes. A copy of the pressure/altitude chart is attached.

## 7.0 PROCEDURE FOR ACTUAL DISSOLVED OXYGEN MEASUREMENT

- 7.1 Place the probe in the sample.
- 7.2 Adjust the salinity control to the salinity of the sample, unless reading % air saturation.
- 7.3 Set the switch to O<sub>2</sub> Zero and readjust if necessary.

- 7.4 Turn the switch to the desired function and read the dissolved oxygen value. Be sure that the sample is being agitated or flowing at approximately one foot per second, or more past sampling membrane surface.
- 7.5 Allow at least 10 to 30 seconds response time before recording the measurement.

## **8.0 QUALITY CONTROL**

- 8.1 Document all calibrations and verification readings, including time and meter readings.
- 8.2 Always store the probe in the calibration chamber with a moist towel to assure 100% humidity and to keep the probe from drying out.
- 8.3 Calibrate the probe daily or after every 10 investigative sample measurements, whichever occurs more frequently.
- 8.4 Change the membrane at least once every two weeks, if bubbles form inside the probe, or if the membrane dries out.
- 8.5 Rinse the probe in clean water after use.
- 8.6 Take duplicate measurements at least once for every 10 investigative samples or daily or whichever is more frequent.

TABLE 1

Calibration Values for various atmospheric pressures and altitudes. Normal barometric variations are equivalent to  $\sim \pm 500$  feet at sea level.

PRESSURE			ALTITUDE		CALIB. VALUE
Inches Hg	mm Hg	kPa	Ft.	m	
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.2	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

## **SURFICIAL SEDIMENT SAMPLING**

### **JOB DESCRIPTION:**

Collect surficial (0 to 6 inches) sediment samples.

### **EQUIPMENT NEEDED:**

- Detailed map of sampling locations
- Sample bottles
- Gloves
- Waders or boat, if necessary
- Life preservers for deep water or swift current
- Safety rope
- Petite Ponar sampler (consolidated sediments)
- Eckman sampler (very loose flocculant sediments)
- Shovel (coarse or hard to sample sediments)
- Stainless steel pan
- Stainless steel spoon or trowel
- Decontamination equipment and supplies

### **EXPECTATIONS:**

Samples will be collected properly. Sample locations will be identified on a map or an aerial photograph. Observations of appearance, texture, color, odor or other sediment characteristics will be noted.

### **PROCEDURES:**

1. Begin sampling at the furthest location downstream and work upstream. Collect water samples before sediment samples.
2. Note your location with reference to one or more mapped or photo-identifiable features (bridge, solitary tree, building, other distinct structure), or by upstream distance from a previous station. Mark your location on a map or aerial photograph.
3. If in a river or stream, position yourself so that you are facing into the flow (if any). Stand downstream of the Ponar sampler so that water flows past the sampler and then past you. When identifying locations, the right bank is the side to your right when looking upstream. Collect the samples from undisturbed areas (depositional, in preference to erosional bottom area).

4. Note flow (smooth, turbulent), depth of water, stream width, weather, and other information as prescribed in Standard Operating Procedure A-5. Note any significant features at or beyond the water's edge such as a gravel bank, large fallen tree, boulder, utility marker, property sign, or high-water mark.
5. Collect the samples with the Ponar unless the sediments are extremely loose or very coarse. If the sediments are very loose, use an Eckman sampler. If the sediments are very coarse, use a shovel.
6. Place the sample into the stainless steel pan and scoop sediments into bottles for volatile organic chemical analyses. Then mix the sediments in the pan and scoop the samples into other appropriate sample bottles. It may be necessary to collect several samples from each location to obtain enough volume of sediment.
7. Record the appearance (color, texture, odor) of the sediments sampled.
8. Number the sample positions in a cross section beginning from the right bank and proceeding across to the left bank.
9. Free water floating on top of the sediment sample should be decanted before the sample is placed in the sample container.

## **SAMPLING GROUND WATER FROM A DOMESTIC WELL**

Sampling ground water from a domestic well is similar to sampling ground water from a monitoring well except that the well, pump, and piping were not designed for environmental sampling. The purpose of the sampling is still to determine the chemistry of the ground water which is collected by the well system. The purpose of the sampling may be changed to determine the chemistry of the drinking water, in which case the sampling procedures described below should be modified.

### **1. SAMPLING TAP LOCATION**

The sample tap should be chosen to provide a water sample most representative of the ground water. The tap should be as close to the well head as possible, prior to any treatment system (water softener) and prior to the storage tank if possible. The water supply system should be inspected and detailed in the field notes to document the location of the well, pump, storage tanks, any treatment systems that may be present, and the sampling tap. A tap without an aerator is preferred. If an aerator is on the sampling tap, the aerator should be removed prior to sampling (if possible) and replaced when finished. Aside from temporarily removing an aerator, WW Engineering & Science personnel should not dismantle any plumbing to access a sample point.

### **2. SYSTEM PURGE**

The well system should be purged by running the tap for at least 15 minutes at medium to high flow levels. To document the purging process, the flow rate and water temperature should be recorded periodically throughout the period. Increasing the flow rate by running additional taps or flushing a toilet may help purge the system. The pipes, any storage tanks, and the well casing need to be purged. If the temperature stabilizes prior to 15 minutes of purging, it is not an indication that the well casing has been purged of the proper volume. However, if the temperature has not stabilized after the 15 minutes, the system should be purged longer until the temperature has remained stable for five minutes.

### **3. SAMPLE COLLECTION**

The sample should be collected using the same procedures and containers as samples from monitoring wells. The flow on the system should be reduced so that the sample is not aerated and so that the preservatives are not spilled. Sample bottles should not come in direct contact with the sampling tap. When required, field measurements and field filtration should be performed immediately upon collection. Thorough field notes are required, and the chain of custody must be documented for all domestic well samples.

After the samples are collected, the area around the tap should be cleaned up so that it is at least as clean as when the sampling began.



## **GRAB SAMPLES OF SURFACE SOILS**

### **JOB DESCRIPTION:**

- Collect surface grab samples of soil.

### **TASK SPECIFIC EQUIPMENT AND MINIMUM INFORMATION REQUIRED**

- sampling device (clean shovel or trowel)
- sampling gloves
- sample bottles
- decontamination materials

### **EXPECTATIONS:**

- The soil encountered will be accurately described.
- Samples will be collected from a fresh surface.
- Locations will be accurately described on a sketch or a base map.

### **PROCEDURE:**

1. Dig a hole in the ground surface to a sufficient depth to expose fresh surface soil.
2. Using clean sampling gloves, scrape the side of the hole with a clean implement (e.g., a knife or tongue depressor) to reach soil that was not contacted by the shovel.
3. Place the sample into the stainless steel pan and scoop sediments into bottles for volatile organic chemical analyses. Then mix the sediments in the pan and scoop the samples into other appropriate sample bottles. It may be necessary to collect several samples from each locations to obtain enough volume of sediment.
4. Discard or decontaminate your sampling device and proceed to obtain the soil sample from freshly exposed soil in the hole. Scrape the soil into the sample jar.
5. Decontaminate the tools with soap and water.
6. Label the location and the sample.
7. Proceed until all the requested samples have been obtained.
8. Sampling devices such as shovels or trowels will be made from stainless steel or other inert materials, not PVC.

## **STANDARD OPERATING PROCEDURE**

### **Field Analysis of Soil Vapor For Volatile Organic Compounds**

#### **Method Description:**

Samples of soil vapor collected in tedlar bags will be analyzed in a temporary field laboratory at the Albion-Sheridan Township Landfill site for the compounds identified in Table A-1. A gas chromatograph with a photoionization detector will be employed for the analyses. Quality assurance objectives for this analysis are given in Table A-2.

#### **Instrumentation and Equipment**

1. Hewlett Packard 5890A GC or equivalent equipped with HNU Model PI-52-02A photoionization detector. Lamp 11.7 ev.
2. Hewlett Packard Model 3392A Integrator.
3. 8-foot SS column. 1/8" OD, packed with 1% SP1000 on 60/80 Carbopack B.
4. Standard materials.
5. 250 ml gas bulbs.
6. Gas tight syringes: 5 ml, 1 ml, 100 ul.
7. Hamilton syringes: 500 ul, 10 ul.
8. 1 liter gas sampling bags (tedlar).

#### **Standard Preparation**

- A. Prepare a mixed solvent stock standard consisting of the chemicals listed in Table A-1 using a 500 ul syringe. Place 500 ul of each liquid compound into a 20 ml vial.
- B. Prepare an intermediate standard by using a 25 ul syringe to place 15 ul of mixed stock into a 250 ml gas sampling bulb which has been purged and filled with nitrogen. Immediately cap and allow the standards to evaporate and equilibrate for approximately 30 minutes at room temperature (20°C). Based on previous experience, this technique is 100% efficient in the volatilization of the standards. The concentrations of the compounds in this bulb are calculated using the following formula.

$$\text{ppm} = \frac{(0.015)/24 \times \text{density (g/ml)} \times 24.45 \times 10^6}{0.250 \text{ L} \times \text{MW (g)}}$$

- C. Prepare a series of three working standards by removing 2.5 cc, 0.25 cc and 0.050 cc from the intermediate standard bulb using gas tight syringes. Inject each volume into clean gas bulbs which have been purged and filled with nitrogen, and allow to equilibrate for 15 minutes. Label the bulbs as Working Standard #1, Working Standard #2, and Working Standard #3.

All standards prepared will be recorded in the standards log book. Intermediate and working standards are to be prepared on a daily basis.

#### Analysis:

##### A. GC Conditions:

1. Injector and detector temperature 210°C.
2. Column program - 50°C for 1 minute then programmed to 210°C at 10°C/min.
3. Detector - 11.7 ev photoionization.
4. Carrier gas - nitrogen (flow rate 30 ml/min).
5. Attenuation as necessary.
6. Injection volume - 1 cc.

##### B. Initial Calibration:

The external standard calibration method will be used for this analysis. Inject the working standards by withdrawing 1 cc from the gas bulbs and injecting onto the GC column. Calculate calibration factors for each compound using the following formula: CF = peak area/compound amount (ppb). Calculate the % RSD for each compound. If the % RSD is  $\leq 25$ , linearity through the origin is assumed and the average CF can be used for calculations. If the % RSD is  $> 25\%$  then re-analyze the three point calibration curve. If reanalysis does not lower the % RSD to  $\leq 25\%$ , then calculations should be based on ratioing the compound against the closest calibration standard. The three point curve will be verified by the analysis of a calibration check standard. This standard will be prepared so as to be equivalent in concentration to working standard #2. Acceptance criteria for this standard is found in Table A-2 under Continuing Calibration.

The RSD is calculated as follows:

$$\% \text{ RSD} = \frac{S(\text{CF1, CF2, CF3})}{\frac{\text{CF1} + \text{CF2} + \text{CF3}}{3}} \times 100$$

where S = standard deviation

### C. Sample Analysis:

Samples will be collected in one liter Tedlar bags and brought to the field laboratory. The samples will be analyzed no later than 12 hours after collection. Typically samples will be analyzed between thirty minutes and two hours after collection. Withdraw 1 cc of sample through the septum using a gas tight syringe. Inject sample onto the GC in the same manner as the standards were injected. Calculate the concentration of the compounds using the following formula:

$$\text{conc (ppb)} = \frac{\text{Area of Compound}}{\text{CF}} \times \frac{1 \text{ cc}}{\text{inj. volume}}$$

If the concentration of the compound exceeds the working range of the curve, re-inject the sample using a smaller volume. Report all results in ppb unless the units become cumbersome, then convert to ppm.

$$\text{By definition: ppb (in air)} = \frac{\text{ug}}{\text{CU meter}} \times \frac{24.45}{\text{MW of compound}}$$

### D. Continuing Calibration:

Calibration should be checked on a regular basis to ensure data quality. After ten samples have been analyzed, re-inject working standard #2. Determine the percent difference (% D) for each compound.

$$\% D = \frac{\text{CF}(\text{new}) - \text{CF}(\text{curve})}{\text{CF}(\text{Curve})} \times 100$$

The % D must be  $\pm 20\%$  of the initial calibration curve. If a compound fails this criteria, re-inject the standard and recalculate the % D. If the compound fails again, a new 3-point calibration curve must be constructed. Samples analyzed prior to this continuing calibration should be re-analyzed if they contain the compound which failed this QC requirement.

Each morning in which analyses are to be run, inject 1 cc of working standard #2. If the % D for each compound is  $\leq 20\%$  of the initial 3-point calibration, analyses may begin. If not, reconstruct a new 3-point calibration curve. Also analyze the calibration check standard. If the % D for each compound is  $\leq 20\%$  of the initial 3-point curve, analyses may begin. If not, reconstruct a new working curve.

### Quality Assurance/Quality Control

In order to verify data quality, duplicate analysis and continuing calibration data will be generated after every ten samples. If these quality control samples do not meet the acceptance criteria outlined in Table A-2, the system is out of control and corrective

action will be initiated. Initially the GC will be checked for problems. If no problems are found, the QC sample which failed will be re-injected. If the problem persists, a new calibration curve will be constructed and the prior group of ten samples will be re-analyzed if necessary.

Additional QC will involve the demonstration of non-detectable contaminants of interest in both field equipment blanks and trip blanks. Both types of blanks will be analyzed after every ten samples. Positive field and/or trip blank data will be reviewed by the laboratory chemist and best professional judgement will be used should the decision involve potential resampling of that days samples.

All quality control results will be recorded in the GC log book. Example calibration and data sheets are provided at the end of this SOP. Any corrective actions or routine maintenance performed on the GC will be recorded in the GC maintenance log.

### **Data Deliverables**

Data deliverables for this project will include the following:

- a. Case narrative describing the method of analysis, problems encountered and corrective action.
- b. Summary of calibration data (initial and continuing).
- c. Summary of sample data by number.
- d. Summary of QA/QC data (blanks, duplicates).
- e. Raw data including chromatograms and calculations.
- f. Instrument and standards log book detailing entries for the project.

### **References**

1. U.S. EPA 1986. Test Methods For Evaluating Solid Waste: Method 3810 - Headspace. Method 8000 - Gas Chromatography. SW846, Third Edition, Volume 1B: Laboratory Manual, Physical/Chemical Methods.
2. GC Operation and Calibration Procedures
  - A. Hewlett Packard 5890A and 3392A. All operation, calibration and maintenance procedures for the Hewlett Packard GC will be in accordance with the factory reference manual, Volumes I and II, and subsequent revisions. All operation and maintenance procedures for the HP 3392A integrator will be in accordance with the factory reference manual (June 1984 and any subsequent revisions).

**B. Photoionization Detector.**

All operation and maintenance procedures for the HNU Model PI-52-02 A photoionization detector will be in accordance with the factory reference manual.

## HEWLETT PACKARD GC CALIBRATION SHEETS

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Sample ID#: \_\_\_\_\_

Location and depth of sample:

\_\_\_\_\_

Description of location:

\_\_\_\_\_

\_\_\_\_\_

Attach strip chart:

Summary of tentatively identified compounds:

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

Others: \_\_\_\_\_

Attach calculations:

## HEWLETT PACKARD GC CALIBRATION SHEETS

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Summarize the types and concentrations of standards:

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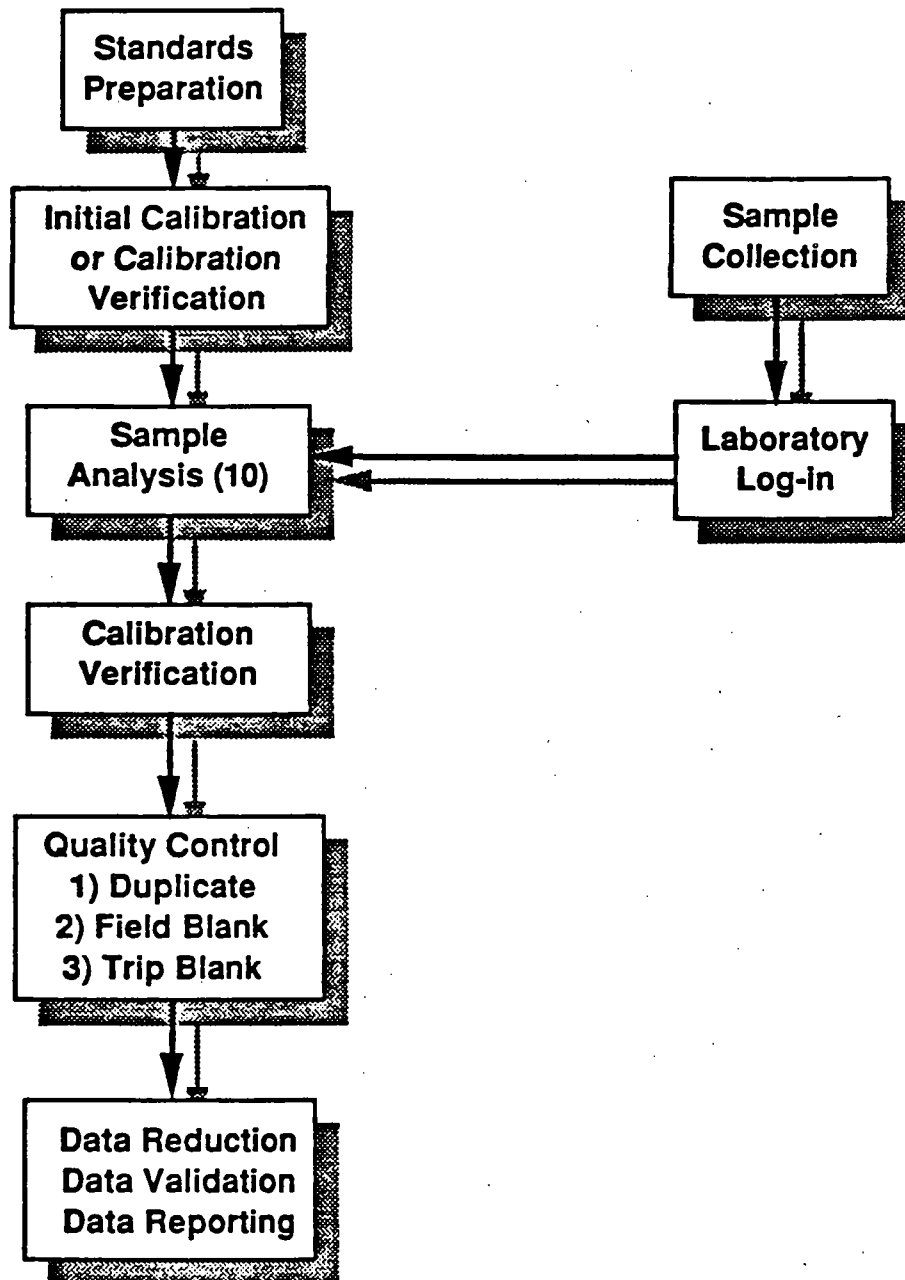
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Attach strip chart:

Calculate peak values (attach calculations):



# ANALYTICAL FLOW CHART



**TABLE A-1**

**LIST OF VOLATILE ORGANIC COMPOUNDS  
FOR FIELD ANALYSIS OF SOIL VAPORS  
ALBION-SHERIDAN TOWNSHIP LANDFILL**

<u>Compound</u>	<u>Detection Limit (ppb)</u>
Benzene	300
Bromodichloromethane	300
Bromoform	300
Bromomethane	300
Carbon Tetrachloride	300
Chlorobenzene	300
Chloroethane	300
2-Chloroethylvinyl ether	300
Chloroform	300
Chloromethane	300
Dibromochloromethane	300
Dichlorodifluoromethane	300
1,1-Dichloroethane	300
1,2-Dichloroethane	300
1,1-Dichloroethylene	300
Trans-1,2-Dichloroethylene	300
1,2-Dichloropropane	300
Cis-1,3-Dichloropropylene	300
Trans-1,3-Dichloropropylene	300
Ethyl benzene	300
Methylene chloride	300
1,1,2,2-tetrachloroethane	300
Tetrachloroethylene	300
Toluene	300
1,1,1-Trichloroethane	300
1,1,2-Trichloroethane	300
Trichloroethylene	300
Trichlorofluoromethane	300
Vinyl chloride	300

**TABLE A-2**

**QUALITY ASSURANCE OBJECTIVES FOR  
SOIL VAPOR ANALYSIS OF ORGANIC COMPOUNDS**

<b><u>Compound</u></b>	<b><u>Calibration Range (ppb)</u></b>	<b><u>Detection Limit (ppb)</u></b>	<b><u>Initial Calibration Criteria % RSD</u></b>	<b><u>Precision % RD</u></b>	<b><u>Continuing Calibration % D</u></b>	<b><u>% Completeness</u></b>
All Compounds listed in Table A-1	300-30,000	300	$\leq 25$	$\pm 20$	$\pm 20$	90

Note: Spiked samples will not be analyzed. The accuracy of calibration procedures and system performance will be verified by continuing calibration.

## **METHANE SAMPLING WITH A DETECTOR TUBE**

### **OPERATING INSTRUCTIONS:**

A detector tube will be used to measure methane concentrations flowing up through the hollow-stem augers.

### **INSTRUMENT DESCRIPTION:**

The kit includes a detector tube and a sampling pump.

### **SAMPLING PROCEDURE:**

1. Break off the ends of a sealed, fresh detector tube in the pump's tip cutter.
2. Insert the detector tube into the pump's sample inlet, with the air flow arrow pointing toward the pump.
3. Line up the red dots on the pump shaft and pump end collar, and pull the pump handle all the way out. The handle automatically locks and the pump begins to draw a 100 cc sample through the detector tube. The sampling is completed in one minute. j
4. Read the methane concentration directly off the scale etched on the detector tube.
5. Take one duplicate sample for every ten methane readings.
6. Properly dispose of the used detector tube and the jbroken ends.
7. Record in field log book the following information; sample location, date, time, and samplers name. Record the measurement taken, detector tube size, and manufacturer.

# **FIELD DETERMINATION OF TEMPERATURE FOR GROUND WATER AND SURFACE WATER**

## **1.0 INSTRUMENTATION**

Thermometer  
Plastic Container

## **2.0 PROCEDURE FOR ACTUAL TEMPERATURE MEASUREMENT**

- 2.1 Place the thermometer in the sample.
- 2.2 Agitate the thermometer in the sample for one minute.
- 2.3 Read the temperature directly off the scale etched on the thermometer.
- 2.4 Repeat until three consecutive readings are obtained.
- 2.5 Take one duplicate reading every ten temperature measurements.
- 2.6 Rinse the thermometer in clean water after use.
- 2.7 Record in field log book the following information; Sample ID, date, time, and Sampler's name. Record the measurement taken and manufacturer of thermometer.

## FIELD FILTERING

A representative water sample is poured into the upper section of a filtration unit and filtered through a 0.45 um membrane filter by means of a vacuum applied to the lower receiving section of the unit.

### Analysis Rate:

Typically, a sufficient sample quantity for laboratory analysis can be field filtered in approximately 15 minutes

### Materials and Apparatus:

Disposable filter units having a capacity of 500-1,000 ml with a 0.45 um cellulose nitrate membrane filter (nalgene 450-0045, 127-0045, or equivalent).

Hand vacuum pump

1/4" ID tygon tubing (approx. 2 feet)

### Procedure:

Open the top of the filtration unit and pour in approximately 25 mls of sample. Attach the hand pump to the hose nozzle on the unit. Slowly apply a slight vacuum to begin filtration. When the 25 ml aliquot is filtered, open the unit and discard the filtrate. Next, reassemble the unit and filter a quantity sufficient to fill the necessary sample bottles.

If the filter should become clogged or impervious, discard the unit and the start the process over with a new unit.

Be sure to use a new filter unit for each sample location.

### Quality Control:

During the sample collection and filtration process, a periodic decon blank will be generated by filtering reagent grade water through a filtering unit in the same manner as a sample. This blank should be tested for all constituents of interest.

### In-Line Filtration:

A disposable 0.45 micron filter cartridge will be used for in-line filtering. The device will be attached to the sample pumping device (either the sampling pump or a peristaltic

pump) by means of silicone tubing. If the filter is attached directly to the sampling pump, it will be attached immediately after well purging has taken place.

The filtering procedure will proceed as follows:

- The sample will be placed in a 1 liter glass bottle.
- The filter cartridge will be attached to the discharge pump by means of silicone tubing.
- The discharge tubing and filter will be held upward so that air can be purged from the filter and tubing during the initial pumping.
- Fill the appropriate sample bottles with filtered water.
- Discard filter and silicone tubing.
- Record in the field log book the following information, sample location, date, time, and the individual's name performing the filtering. Record the manufacturer and size of filter.

## ***Appendix B***

---

### ***ASTM Procedures***



**AT THIS TIME COPYRIGHT APPROVAL  
IS BEING SOUGHT FOR INCLUSION  
OF THESE METHODS**

## **Appendix C**

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### **Packer Test Method - Test Designation E-18**

## Designation E-18

**1. Scope.**—This designation describes water tests for determining the approximate values of permeability of individual strata penetrated by borings. The reliability of the values obtained depends on the homogeneity of the stratum tested and on certain restrictions of the mathematical formulas used. However, if reasonable care is exercised in adhering to the recommended procedures, useful results can be obtained during ordinary boring operations.

Another procedure for computing permeability is found in Geology Report G-97<sup>1</sup>, which is available from the Engineering and Research Center. Either procedure is acceptable. When submitting permeability test results, the formulas used should be included with the data.

**2. Apparatus.**—These tests are not required for construction control; therefore, the apparatus is not listed in the field laboratory equipment list, designation E-4.

(1) For open-end tests (fig. 18-1), a drill rig or other means of excavating a borehole and driving pipe casing is needed. (*Note:* Drilling mud or other additives must not be used in unconsolidated materials.) A watermeter, pressure gage, pump, and the necessary water pipe and connections are also required.

(2) For packer tests (fig. 18-2), a supply of packers, perforated water pipe, and necessary fittings are needed in addition to the equipment listed under (1) above.

**3. Water.**—The following tests are of the pumping-in type, that is, they are based on measuring the amount of water accepted by the ground through the open bottom of a pipe or through an uncased section of the hole. Unless clear water is used, these tests are invalid and may be grossly misleading. The presence of even small amounts of silt or clay in the added water will result in plugging of the test section and give permeability results that are too low. By means of a settling tank or a filter, efforts should be made to assure that only clear water is used. It is desirable for the temperature of the added water to be higher than ground-water temperature, so as to preclude the creation of air bubbles in the ground which may greatly reduce the acceptance of water.

**4. Open-End Tests.**—(a) *Procedure.*—Figures 18-1 (A) and (B) show tests made through the open end of a pipe casing which has been

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<sup>1</sup> "Permeability Tests Using Drill Holes and Wells", Geology Report No. G-97, Research and Geology Division, Bureau of Reclamation, January 3, 1951.

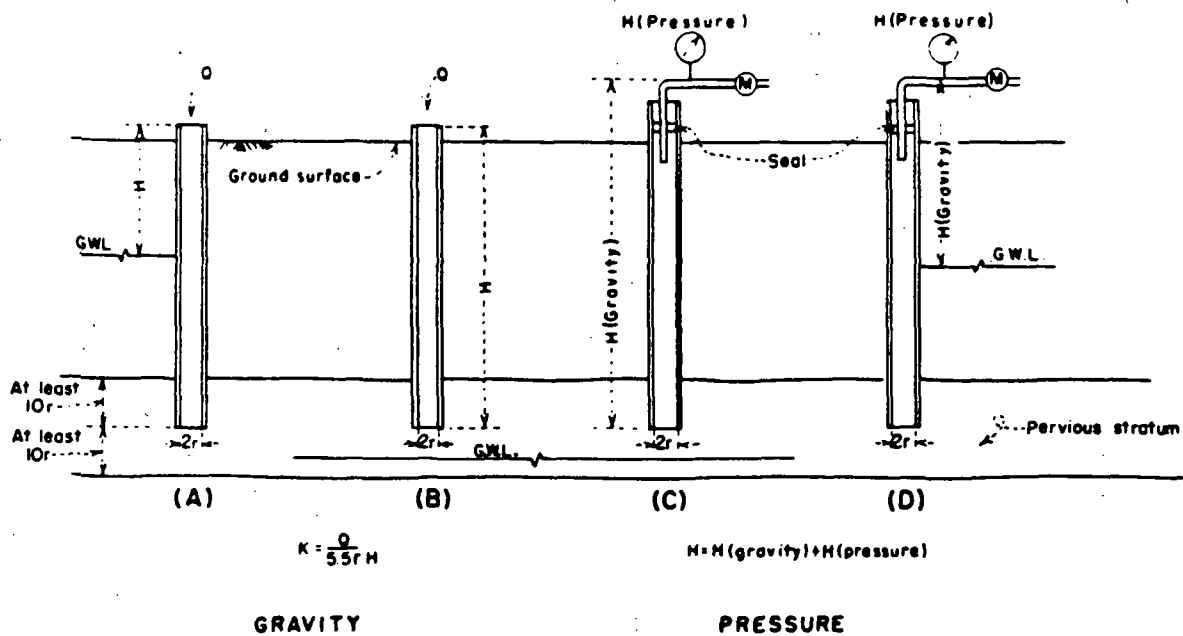


Figure 18-1.—An open-end pipe test for soil permeability which can be made in the field. PX-D-16267.

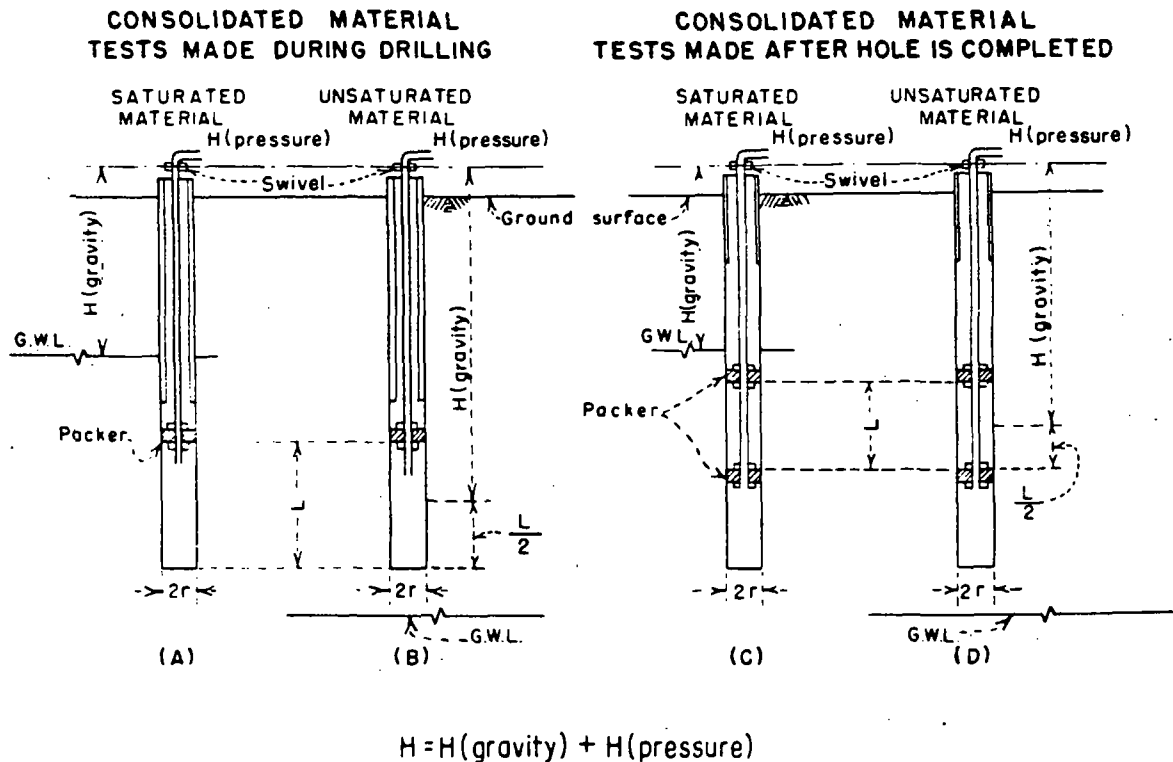


Figure 18-2.—The packer test for soil permeability. PX-D-4785.

sunk to the desired depth and which has been carefully cleaned out just to the bottom of the casing. When the hole extends below the ground-water table, it is recommended that the hole be kept filled with water during cleaning and especially during withdrawal of tools to avoid squeezing of soil into the bottom of the pipe. After the hole is cleaned to the proper depth, the test is begun by adding clear water through

a metering system to maintain gravity flow at a constant head. In tests above the water table (fig. 18-1 (B)) a stable, constant level is rarely obtained and a surging of the level within a few tenths of a foot at a constant rate of flow for about 5 minutes is considered satisfactory.

If it is desired to apply pressure to the water entering the hole, the pressure, in units of head, is added to the gravity head as shown in figures 18-1 (C) and (D). Measurements of constant head, constant rate of flow into the hole, size of casing pipe, and elevations of top and bottom of casing are recorded. The permeability is obtained from the following relation determined by electric analogy experiments:

$$k = \frac{Q}{5.5rH} \quad (1)$$

where:  $k$  = permeability,

$Q$  = constant rate of flow into the hole,

$r$  = internal radius of casing, and

$H$  = differential head of water.

Any consistent set of units may be used. For convenience, if  $k$  is measured in feet per year,  $Q$  in gallons per minute, and  $H$  in feet, equation (1) can be written:

$$k = C_1 \frac{Q}{H}$$

Values of  $C_1$  vary with the size of casing as follows (see figs. 2-18 through 2-22):

Size of casing	EX	AX	BX	NX
$C_1$ -----	204,000	160,000	129,000	102,000

The value of  $H$  for gravity tests made below water table is the difference in feet between the level of water in the casing and the ground-water level. For tests above water table,  $H$  is the depth of water in the hole. For pressure tests the applied pressure in feet of water (1 pound per square inch = 2.31 feet) is added to the gravity head to obtain  $H$ .

(b) *Example for Condition Shown in Figure 18-1 (A).*—  
Given: NX casing

$Q = 10.1$  gallons per minute

$H = 21.4$  feet

$$k = C_1 \frac{Q}{H} = \frac{(102,000) (10.1)}{21.4} = 48,100 \text{ feet per year.}$$

(c) *Example for Condition Shown in Figure 18-1 (D).—*

Given: NX casing

 $Q = 7$  gallons per minute $H$  (gravity) = 24.6 feet $H$  (pressure) = 5 p.s.i. =  $5 \times 2.31 = 11.6$  feet of water.Then:  $H = 24.6 + 11.6 = 36.2$  feet

$$k = C_1 \frac{Q}{H} = \frac{(102,000) (7)}{36.2} = 19,700 \text{ feet per year.}$$

**5. Packer Tests.**—(a) *Procedure.*—Figure 18-2 shows a permeability test made in a portion of a drill hole below the casing. This test can be made both above and below the water table provided the hole will remain open. It is commonly used for pressure testing of bedrock using packers, but it can be used in unconsolidated materials where a top packer is placed just inside the casing. When the packer is placed inside the casing, measures must be taken to properly seal the annular space between the casing and drill hole wall to prevent water under pressure from escaping.

The formulas for this test are:

$$k = \frac{Q}{2\pi LH} \log_e \frac{L}{r}; L \geq 10r \quad (2)$$

$$k = \frac{Q}{2\pi LH} \sinh^{-1} \frac{L}{2r}, 10r > L \geq r \quad (3)$$

where:  $k$  = permeability,  
 $Q$  = constant rate of flow into the hole,  
 $L$  = length of the portion of the hole tested,  
 $H$  = differential head of water,  
 $r$  = radius of hole tested,  
 $\log_e$  = natural logarithm, and  
 $\sinh^{-1}$  = inverse hyperbolic sine.

These formulas have best validity when the thickness of the stratum tested is at least  $5L$ , and they are considered to be more accurate for tests below ground-water table than above it.

For convenience, the formulas can be written:

$$k = C_p \frac{Q}{H}$$

where  $k$  is in feet per year,  $Q$  is in gallons per minute, and  $H$  is the head of water in feet acting on the test length. Where the test length is below the water table,  $H$  is the distance in feet from the water table to the water swivel (see fig. 18-2) plus applied pressure in units of

feet of water. Where the test length is above the water table,  $H$  is the distance in feet from the center of the length tested to the swivel plus the applied pressure in units of feet of water. For gravity tests (no applied pressure) measurements for  $H$  are made to the water level inside the casing (usually the level of the ground).

Values of  $C_p$  are given in the following table for various lengths of test sections and hole diameters:

Length of test section in feet, $L$	$C_p$ values			
	Diameter of test hole			
	EX	AX	BX	NX
1-----	31,000	28,500	25,800	23,300
2-----	19,400	18,100	16,800	15,500
3-----	14,400	13,600	12,700	11,800
4-----	11,600	11,000	10,300	9,700
5-----	9,800	9,300	8,800	8,200
6-----	8,500	8,100	7,600	7,200
7-----	7,500	7,200	6,800	6,400
8-----	6,800	6,500	6,100	5,800
9-----	6,200	5,900	5,600	5,300
10-----	5,700	5,400	5,200	4,900
15-----	4,100	3,900	3,700	3,600
20-----	3,200	3,100	3,000	2,800

The usual procedure is to drill the hole, remove the core barrel or other tool, seat the packer, make the test, remove the packer, drill the hole deeper, set the packer again to test the newly drilled section, and repeat the test (see fig. 18-2 (A)). If the hole stands without casing, a common procedure is to drill it to final depth, fill with water, surge it, and bail it out. Then set two packers on pipe or drill stem as shown in figures 18-2 (C) and (D). The length of packer when expanded should be at least five times the diameter of the hole. The bottom of the pipe holding the packer must be plugged and its perforated portion must be between the packers. In testing between two packers, it is desirable to start from the bottom of the hole and work upward.

(b) *Example for Condition Shown in Figure 18-2 (A).—*

Given: NX casing set to depth of 5 feet

$Q = 2.2$  gallons per minute

$L = 1$  foot

$H$  (gravity) = distance from ground-water level to swivel  
= 3.5 feet

$$H \text{ (pressure)} = 5 \text{ p.s.i.} \times 2.31 = 11.6 \text{ feet of water}$$

$$H = H \text{ (gravity)} + H \text{ (pressure)} = 15.1 \text{ feet.}$$

From table,  $C_p = 23,300$

$$K = C_p \frac{Q}{H} = \frac{(23,300)(2.2)}{15.1} = 3,400 \text{ feet per year.}$$



## ***Appendix D***

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### ***Sample Calibration for Soil Vapor Surveys***

## **SAMPLE PUMP CALIBRATION**

Instruction Manual  
for the

---

**Gilian**

**The Gilibrator™**

---

Primary Standard Airflow Calibrator  
with Interchangeable Flow Cell Assemblies

Flow Cell Assembly Ranges

Low : 1 to 250 cc/min.

Standard : 20 cc/min to 6 LPM

High : 2 to 30 LPM

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Gilian Instrument Corp.  
8 Dawes Highway Wayne, NJ 07470-6217  
(201) 831-0440

### Prologue

This Instruction Manual describes the basic principles, installation, operation/controls and maintenance for the Gilibrator, Primary Standard Airflow Calibrator manufactured by Gillian Instrument Corp. Wayne, N.J.

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### Table of Contents The Gilibrator

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## Section 1 Introduction

The Gilibrator is a high accuracy, electronic bubble flowmeter that provides instantaneous air flow readings and a cumulative averaging of multiple samples. The Gilibrator system provides a large dynamic range through the use of 3 interchangeable flow cell assemblies. A delete function, on the Control Unit, subtracts erroneous readings to insure accurate data. The Control unit also supports a hard copy print out through the use of a printer accessory.

## Section 2 General Description (See fig. 1a)

The Gilibrator is comprised of the following basic components: Flow Cell Assembly, Control Unit (base), Battery Charger and Soap Solution. Different sized interchangeable Flow Cell Assemblies are available for use as follows:

Low Flow : 1 to 250 cc/min.  
Standard Flow : 20 cc/min to 6 LPM  
High Flow : 2 to 30 LPM

In addition to the basic components, an optional Printer Module is available. The printer provides a hard copy record of calibration data; however, identical data is displayed on the LCD of the Gilibrator Control Unit during calibration.

### 1. Flow Cell Assembly (See fig. 1b)

The Flow Cell Assembly consists of a Bubble Generator and Sensor Block. Each Bubble Generator is sized to produce a bubble film stretched across the diameter of the flow cell tube which is carried by airflow from the bottom to top of the tube. As the bubble traverses past two infrared sensors, each sensor transmits a signal to the Control Unit (base) indicating the passage of the film. The Flow Cell Assembly incorporates a manual bubble initiation push button which starts the film on its travel up the tube.

#### A. Bubble Generator

1) Flow Ranges  
Low Flow : 1 to 250 cc/min.  
Standard Flow : 20 cc/min to 6 LPM  
High Flow : 2 to 30 LPM

2) Pulsation Damper (2) - a built-in damper smoothes out any pulsation within the airflow and reduces oscillation of the bubble film assuring maximum accuracy.

3) Bubble Initiate Button (22) - This pushbutton lowers the Bubble Generator Ring (21) into the soap solution reservoir. Upon releasing the button, the ring lifts out of the soap solution and a film bubble is generated across the opening of the flow tube (24).

4) Bubble Breaker (4) - The Bubble Breaker is a secondary chamber in the upper chamber which provides the soap film a rapid expansion path which is instrumental in breaking the bubble. This prevents excessive wall wetting by the soap film and allows it to flow back into the cell.

5) Storage Tubing (23) - This anti-spill tubing connects upper and lower cell chambers and prevents the soap solution from evaporating which may cause the solution concentration to change.

**CAUTION:** If transporting by plane, be sure to disconnect this hosing from upper or lower Flow Cell Chamber Bosses (23 & 26) to prevent pressurization and possible rupture within the Bubble Generator.

**B. Sensor Block (8)**

Surrounding the flow tube (24) and secured between the upper and lower chamber of the bubble generator, is the Sensor Block (8). The block incorporates lower and upper sensors for time start and time stop. The sensors consist of an infrared emitter and detector pairs whose sensitivity and accuracy is controlled by a "columnating slot". This block is secured to the Bubble Generator Assembly (1) by means of two Locking Screws ((7) and allows easy removal to facilitate cleaning.

1) Electrical Interface - The Electrical Interface provides power to the sensing system as well as transmits timing information to the Control Unit.

**2. The Control Unit (base) (See fig. 1a)**

The Control Unit (14) contains a crystal controlled timing system, a micro processor control system, and an LCD readout for displaying flow and messages. The Control Unit also contains switches for Reset (17), Delete (16) and Auto-Averaging (15) functions as well as an Printer Jack (18) interface port for direct connection to a hard copy printer. LED indicators are provided to note Charging (11) and Run calibration (20) operation.

a) Power (12) - switch turns the Control Units power on and off.

b) Charge Indicator LED (11) - lights when the charger is plugged into the Charging Jack

c) Printer Jack (18) - provides interface for auxiliary printer.

d) Reset (17) - push button deletes all current information for the micro processor in order to initiate a new sequence.

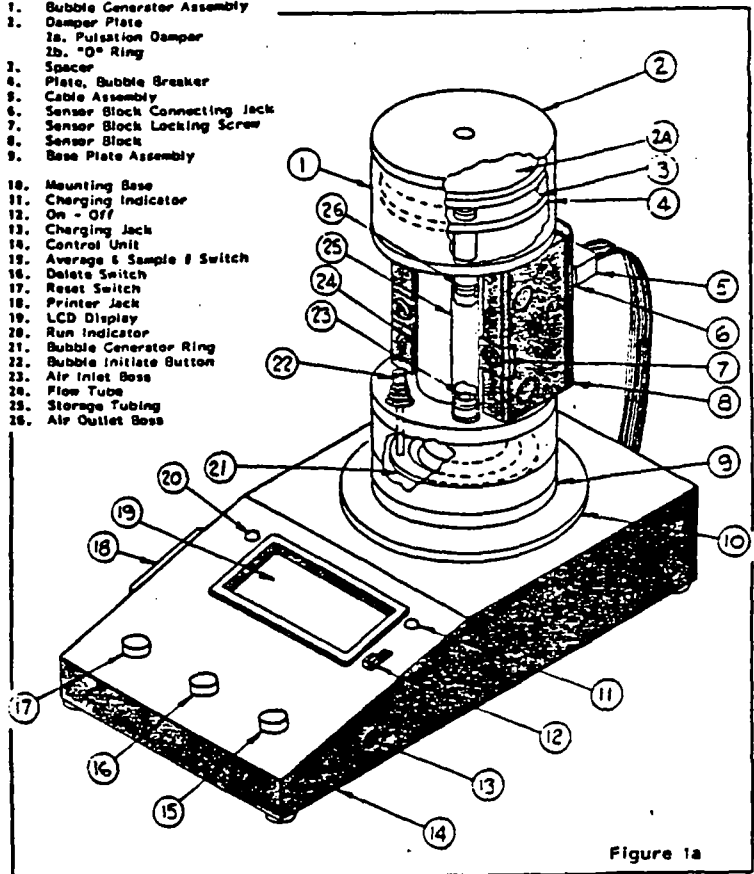
e) Delete (16) - push button automatically deletes false information from the average and will reset the average and sample number to the previous reading. When a printer is in line, this will indicate a minus symbol and the average will return to the previous value.

- f) Average (15) - push button when pushed and held will display the average of the previous sequence of readings. When released will display the last actual reading and when re-pushed and held, will show the number of samples in the sequence with display information (5=sample #). Releasing the button will automatically bring the display back to the last reading.
- g) Sequence Run Indicator LED (20) - indicates bubble sequence by lighting as the bubble passes between the two sensors. The LCD (19) will be blank. The Run signal will also light when turning on the Control Unit and will extinguish after unit has finished its initial sequence check.
- h) Low Battery - will indicate on the LCD display (19) if insufficient battery voltage is available to operate the unit properly. Since power for all Control Unit functions is derived from the rechargeable NiCad battery, the batteries must be fully charged for proper operation. A "Low Battery" indication will also appear initially when turning the Control Unit ON as a sequence check of the unit's electronics.
- i) Cable Assembly (5) - mates with the Connecting Jack (6) in the back of the Sensor Block. It provides power for the sensing system, information regarding cell size, and control of the timing information to the micro processor.
- j) Timing System - The quartz controlled timing system controls infrared sensor activation to assure maximum calculation accuracy.
- k) Micro Processor - controls the timing and mathematical data processing to provide optimum flow measurement characteristics. This programmable micro processor can be upgraded as new programs become available.
3. Battery Charger  
Standard wall operated 120V charger to charge Gilibrator Control Unit for 12 hours prior to operation. The Charging LED on the Control Unit will be illuminated while charging is in progress.
4. Soap Solution  
This specially compounded low residue soap is specifically designed to provide high film strength and compatibility with the materials used within the Flow Cell Assembly.

**The Gliberator System**  
**The Gliberator**

**Nomenclature**

1. Bubble Generator Assembly
2. Dampor Plate
  - 2a. Pulsation Dampor
  - 2b. "O" Ring
3. Spacer
4. Plate, Bubble Breaker
5. Cable Assembly
6. Sensor Block Connecting Jack
7. Sensor Block Locking Screw
8. Sensor Block
9. Base Plate Assembly
10. Mounting Base
11. Charging Indicator
12. On - Off
13. Charging Jack
14. Control Unit
15. Average & Sample # Switch
16. Delete Switch
17. Reset Switch
18. Printer Jack
19. LCD Display
20. Run Indicator
21. Bubble Generator Ring
22. Bubble Initiate Button
23. Air Inlet Boss
24. Flow Tube
25. Storage Tubing
26. Air Outlet Boss



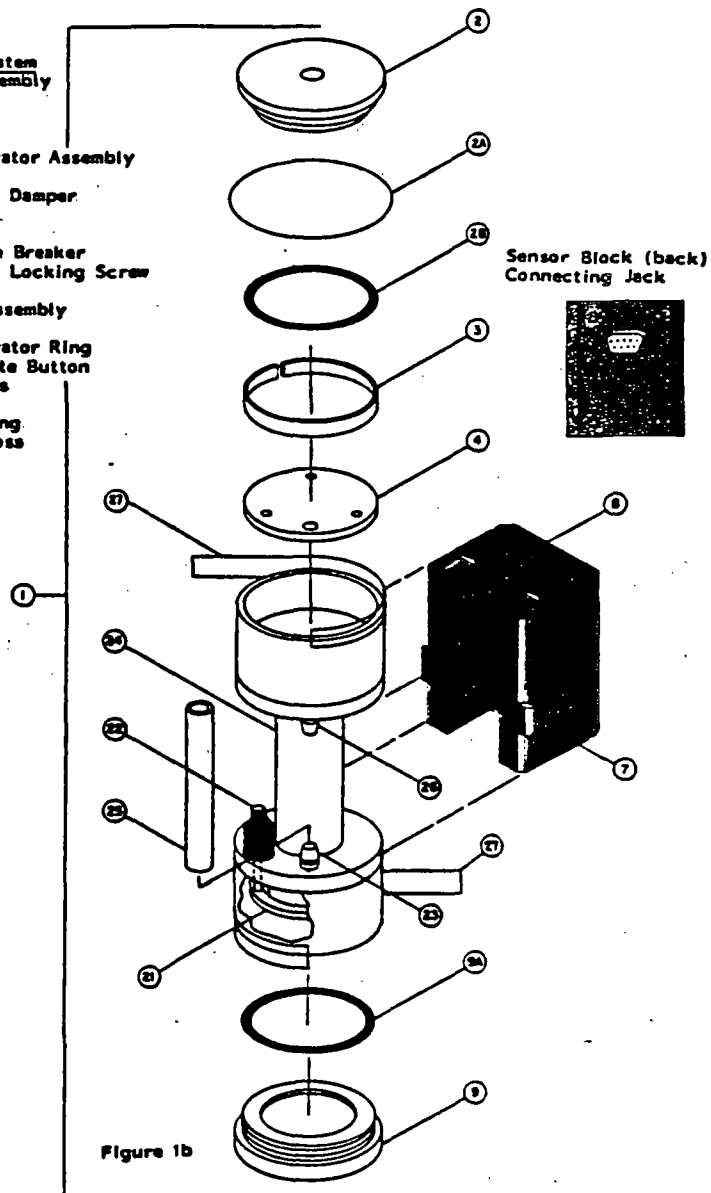
**Figure 1a**



**The Gillibrator System  
The Flow Cell Assembly**

**Nomenclature**

1. Bubble Generator Assembly
2. Damper Plate
  - 2a. Pulsation Damper
  - 2b. "O" Ring
3. Spacer
4. Plate, Bubble Breaker
7. Sensor Block Locking Screw
8. Sensor Block
9. Base Plate Assembly
  - 9a. "O" Ring
21. Bubble Generator Ring
22. Bubble Initiate Button
23. Air Inlet Boss
24. Flow Tube
25. Storage Tubing
26. Air Outlet Boss
27. Safety Tape



**Figure 1b**

Section 3  
Theory of Operation

1. Primary Airflow Standard

To be a primary standard, all values must be absolute and measured as absolute. A primary standard airflow measurement is a volume divided by a time interval as performed by the Control Unit of the Gilibrator. The volume,  $V$ , is measured volume of space between two infrared sensors. The time is that interval needed for a soap film bubble to traverse between the two sensors which bound the volume. Therefore,  $V/t$ , the volume per unit of time, becomes the airflow and is prime because all measurements are basic... volume and time. In today's technology, time is measured by an electronic clock whose accuracy exceeds that of volume measurements by orders of magnitude, hence, the control accuracy volume resides solely with volume measurements.

2. Bubble Generation and measurement

a) The Gilibrator consists of two elements, the Flow Cell Assembly and the Control Unit (base). The function of the Flow Cell Assembly is to generate a clean consistent bubble which traverses up the flow tube. Measurement of the traverse time is done by infrared sensor pairs which are mounted at the bottom and the top of the Sensor Block. The volume bound by these sensors is specifically adjusted to a volume standard by allowing the upper sensor blocks to move in unison so as to enable this calibration to be set accurately to a primary volume standard. A second function of the sensor block provides the interfacing code to define the cell volume as well as sensitivity adjustments for the optical sensor systems.

b) As the bubble traverses between the sensors, first one and then the second, sensors are tripped thereby providing the time for the bubble traverse. This timing information is sent to the micro processor of the control base which in turn provides the crystal control time base for the system. The timing information along with the volume information are then sent to the micro processor which in turn does the necessary mathematical calculations which allow the flow to be displayed directly on the LCD readout. In order to insure the highest accuracy possible, a Delete and Average function are provided on the Control Unit. The Delete allows for subtracting out an obvious malformed bubble and the average allows the user to obtain average information without pencil or paper. A printer interface allows connection of a Printer Module so that hard copy can be produced.

Section 2  
Operating Procedures

1. Initial Set-up

This covers all steps necessary to bring the Cillibrator into operating status. This includes charging, cell mounting, installing the soap solution, connecting the printer (optional) and connecting the sampling source.

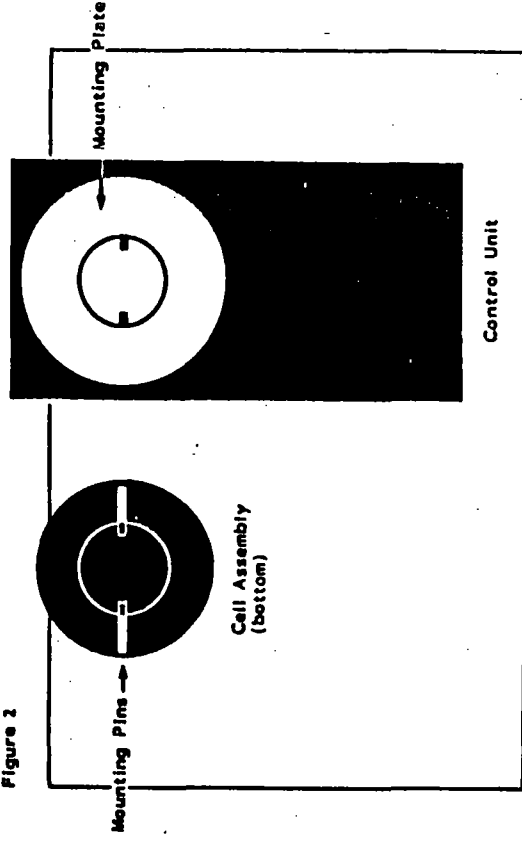
A) Charging the Cillibrator

1. Prior to operation, plug the 120V charger into the wall and connect to the Charging Jack (13) on the right side of the Control Unit. The unit's Charging LED (11) will light indicating that the unit is charging properly. Allow the battery system to charge for 18 hours prior to operation.

B) Mounting the Flow Cell Assembly (See fig. 2)

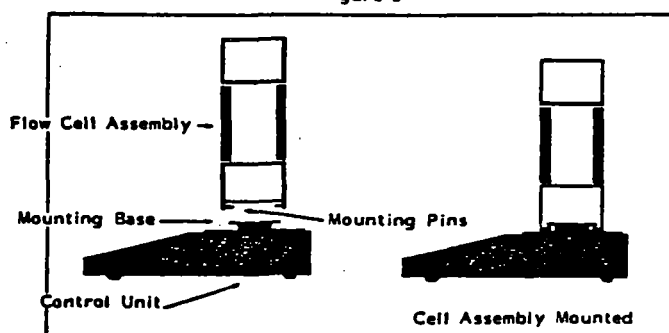
1. Select the Flow Cell Assembly to cover the flow range required.
2. The bottom of the Flow Cell Assembly employs a quick mount feature. The base of the Flow Cell Assembly is positioned onto the mounting plate (10) of the Control Unit (18).

Figure 2



3. Engage the pin of the cell assembly base into the mounting plate of the Control Unit. When the Flow Cell Assembly is properly engaged, the base of the cell will be flush to the mounting plate and the cell assembly will face towards either the right or left side. (See fig. 3)

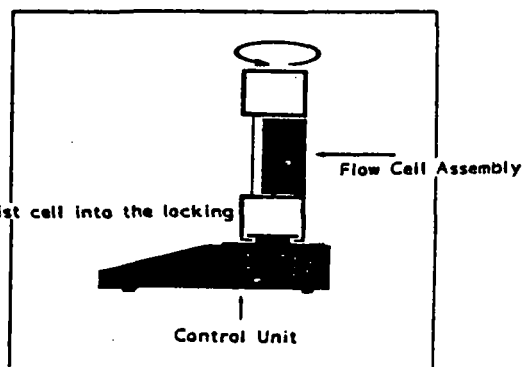
Figure 3



4. Grasp the bottom cell chamber and rotate the cell until it clicks in. CAUTION: Always engage & disengage the cell by grasping and rotating only the bottom cell chamber. The cell assembly will now face forward. (see Fig. 4)

Figure 4

Firmly twist cell into the locking position



3. Insert the Control Unit's Cable Assembly (5) into the Sensor Block Connecting Jack (6) located on the back of the Sensor Block (8). (See Fig. 3)

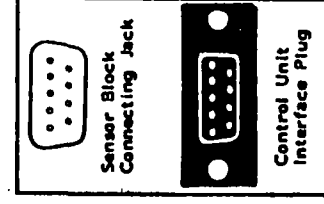
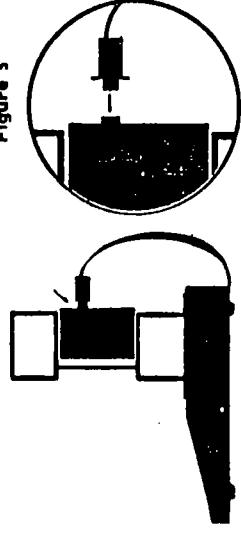


Figure 3



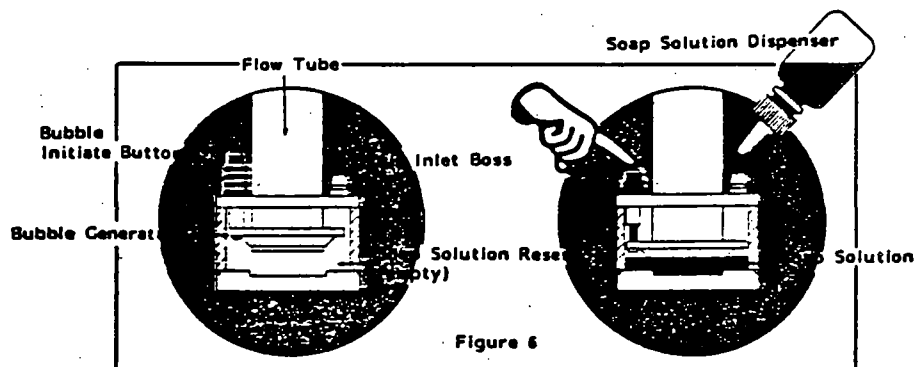
Connecting the Control Unit's Interface Plug to the Sensor Block's Connecting Jack.

#### C) Adding the Gillibrator Soap Solution

1. Remove the Storage Tubing (23) from the upper Outlet Boss (26) of the upper cell. Fill the dispenser bottle provided with Gillibrator soap solution. Using the rubber Storage Tubing as a funnel, slowly add soap solution from the dispenser.
2. The amount of soap needed is determined by depressing the Bubble Initiate Button (22) and holding it down in the lower position. Continue to add enough soap solution until the angled edge at the bottom of the Bubble Generator Ring (21) is immersed in the solution. Do Not Overfill! (See Fig. 6)
3. After filling is completed, the rubber Storage Tubing (23) may be removed completely. Recap the soap dispenser bottle for later use. NOTE: If the Flow Cell Assembly is not going to be used for a prolonged period of time, reinstall the rubber Storage Tubing between the inlet and outlet bosses (23 & 26). This will prevent evaporation from occurring which may cause the solution's concentrations to alter.

#### D) Printer Connection (If applicable)

1. Connect printer cable to Printer Jack connector (18) on the left side of the Control Unit. Be sure to properly match up connectors before engaging.



#### E) Connect the Sampler

1. Connect the air sampler to be calibrated to the Upper Outlet Boss (26) of the Flow Cell Assembly with 1/4" ID tubing. NOTE: An auxiliary liquid trap between sampler and flow cell is recommended to prevent moisture carry over into the sampler during continuous calibration periods.

### 2. Operation

#### A) Conditioning the Flow Tube

1. Turn on the sampler. Depress the Bubble Initiate Button (22) several times to wet the inner walls of the flow tube (24). You will not be able to initiate a timing bubble without first "Priming" the flow tube. The operator will develop a feel for bubble generation with practice.

#### B) Power Up

2. After the Flow Tube walls have been "primed", turn on the Power Switch (12) of the Gillibrator Control Unit (base) and the Printer Module if one is being used. Wait approximately 10 seconds while the system runs through it's check sequence. The Run LED (20) will light at this time as well as a Lo Battery indication and a series of five dashes displayed on the LCD Readout (19). Do not operate the Gillibrator until the Run LED signal extinguishes. Ready operation is indicated by a series of 5 dashes.

#### C) Bubble Generation

1. For optimum bubble generation, depress the Bubble Initiate Button (22) and hold to initiate 1 bubble up the flow tube. Release the button to initiate a second bubble up the flow tube. This will be the standard procedure to making clean, consistent bubbles at High and Medium flow ranges.

2. As the bubble rises up the Flow Tube (28), it will initiate a timing sequence when it passes the lower sensor (Run LED will light) and culminate the timing sequence upon passing the upper sensors (Run LED will extinguish). The timing information is then transmitted to the control unit which will perform all the necessary calculation. A flow reading will instantaneously appear on the LCD display (19).

However, if a bubble breaks before the time sequence is completed, timing will continue until another bubble is generated to trip the second sensors. This will cause an erroneous reading and should be subtracted from the average by hitting the Delete Button (16).

If a Printer Module is used, be sure the printer has completed its printing sequence before pressing the Delete Button. When the Delete Button is activated, a negative symbol will be displayed on the LCD of the Control Unit and the printer will initiate a line showing this subtraction.

#### **D) Flow Readout**

**With Printer Option** - The printer will print in sequence the flow, average and sample number of each successive bubble reading.

**Without Printer Option** - The Control Unit will display the actual flow for each sample and will accumulate and average each successive reading.

1. **Average (15)** - In order to display average and number of samples, depress and hold the Average Button. Releasing the button will display the last flow reading. Repressing the button will display the number of samples accumulated for that averaging sequence and releasing will once again display the last flow reading. Additional pressing and holding will repeat this sequence.

2. **Delete (16)** - To delete obvious false readings, push the Delete Button which will automatically delete the false information from the average and reset the average and sample number back to the previous reading.

3. **Reset (17)** - To reinitiate the sequence for additional pumps, hit the Reset Button. This will zero out all sample and average registers within the Control Unit and will cause the printer to index online and reprint sequence headings. This denotes the start of a new sequence. The Reset Button is also used if a malformed bubble is generated and has not been subtracted from the average by use of the Delete Function.

**Section 5**  
**Storage & Maintenance**

**1. Storage**

**A. Take Down**

Turn OFF the Control Unit, the sampler and the Printer Module (if applicable).

**B. For Daily Use**

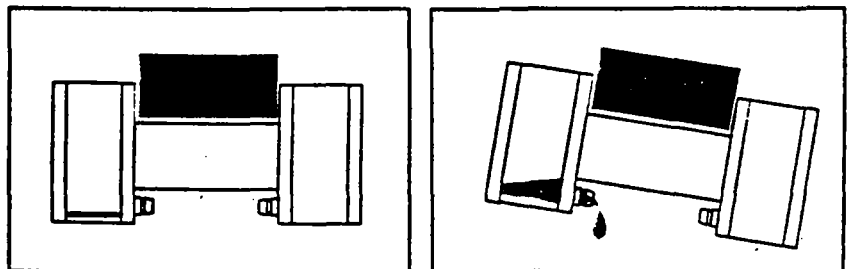
If Cilibrator is to be used daily, it is recommended that the air sampler be removed and the Storage Tubing be replaced between the upper and lower cell chambers. Plug in the Charger and connect into the Control Unit Charging Jack (13). Recharge overnight for next day usage.

**C. Long Term Storage**

If the Cilibrator is not to be used for long periods of time, the following steps should be taken to keep the unit in proper working order.

1. Disconnect the Cable Assembly from the back of the Sensor Block on the Flow Cell Assembly.
2. Remove the Flow Cell Assembly from the Control Unit (base). Remove the Cell from the base in the reverse order in which it was mounted.
3. Pour soap solution out of the Bubble Generator through the Lower Inlet Boss (23) By holding Bubble Generator horizontally and with the inlet boss facing down, tilt at a 45 degree angle. Continue until all of soap solution has poured out. (See fig. 7)

**Figure 7**





4. Flushing the Bubble Generator Clean - There are 2 methods in which to cleanse the Bubble Generator.

a. The unit may be flushed clean by connecting Storage Tubing to the Upper Outlet Boss and continuously running water through the generator until water runs clear. Maintain a horizontal position with cell bosses facing down and flush for 15 - 30 seconds. Then remove tubing and rock the cell in a see-saw fashion to empty out all excess water. Replace Seal Tubing between the Upper and Lower Cell bosses.

(See fig. 8)

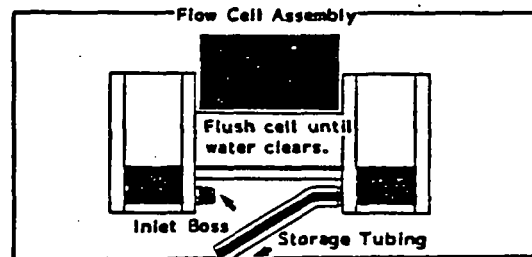
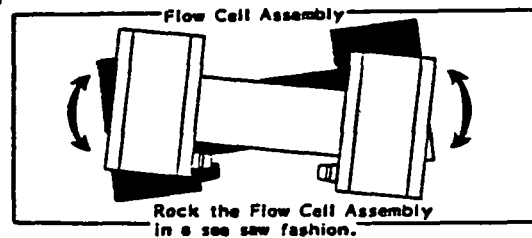


Figure 8



or (see Figure 9)

b. Remove the Sensor Block Assembly by loosening the 2 holding screws and sliding the block out from between the Upper & lower cell chambers. Remove Safety Tape. Using a small flat blade screw driver, lift off the Damper Plate (2) using the notch between the upper chamber and the lid. Remove the Spacer (3) and then the Bubble Breaker Plate (4). This gives complete access to the interior of the Flow Cell Tube. Continue to run clear water through the cell until water runs clear. Rock cell to empty out all excess water. Replace the Bubble Breaker Plate (4) and center the Air Outlet Boss (16) with the plates largest hole. Next insert the spacer. To replace the Damper Plate assembly, moisten the O-ring (2b) with soap solution and then press the Damper Plate into the top of the Upper Cell Chamber. Use fingers and firmly squeeze plate into upper flow cell chamber.

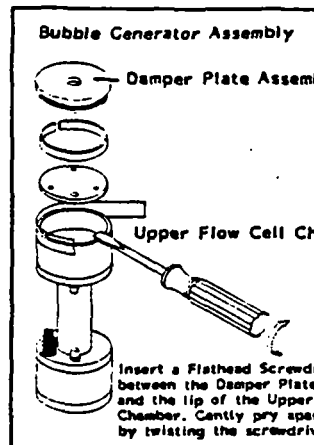
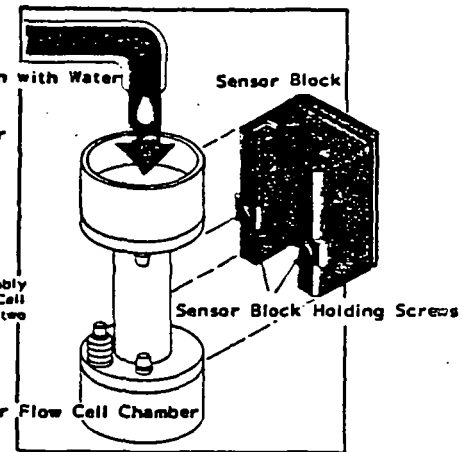
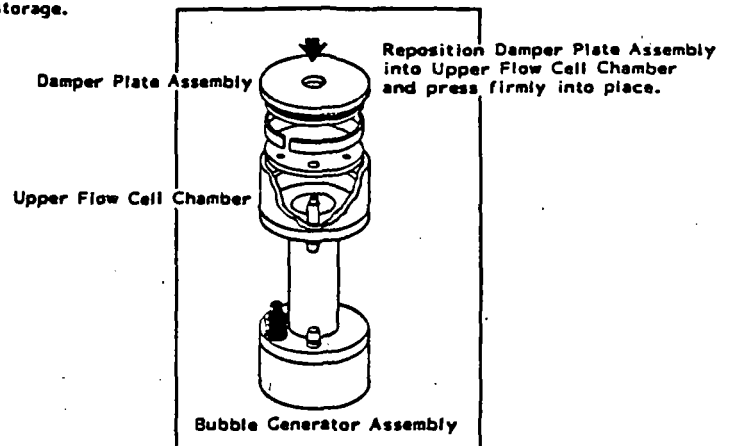


Figure 9



Do Not exert your body weight on the Bubble Generator to press plate into place. Excessive weight on the flow cell may result in breakage.

Replace the Seal Tubing between the Upper and Lower cell bosses for storage.



## 2. Maintenance

The Gillibrator is designed so that little maintenance is required. The area which may need replacement is the Damper Diaphragm assembly. If the diaphragm becomes ruptured or worn please use the following procedure for its replacement.

### a. Removing and Replacing Damper Plate Diaphragm

First, remove flexible Safety Tape (27) from around the lip of the Damper Plate assembly. 1) Using a small flat blade screwdriver, remove the Damper Plate (2) from the Upper Cell Chamber using the notch provided. Remove the large O-ring (2b) and the Pulsation Damper diaphragm (2a). (See fig. 10)

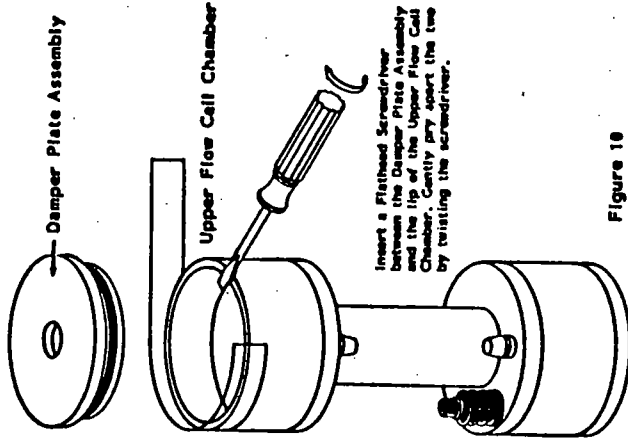


Figure 11

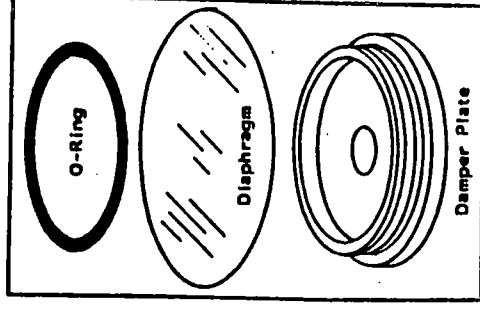


Figure 10

Bubble Generator Assembly

2) To replace, center new diaphragm over Damper Plate aperture and roll O-ring over diaphragm and into the O-ring groove. If wrinkles occur, repeat the procedure to achieve a smooth placement. (See fig. 11)

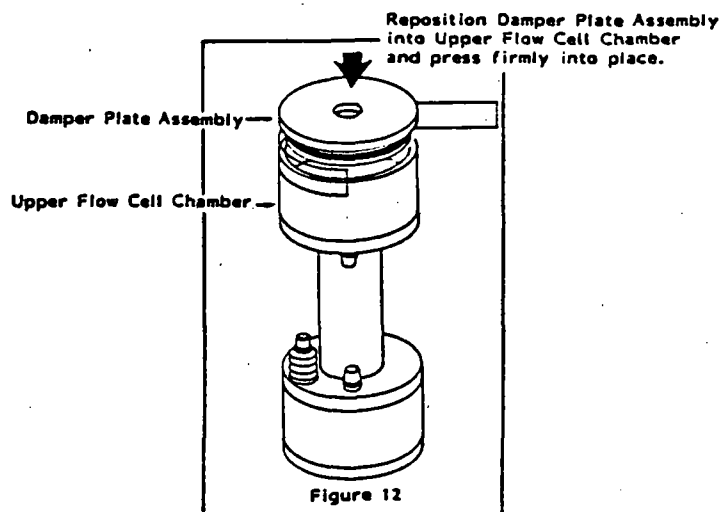


Figure 12  
Bubble Generator Assembly

3) Wet "O"-ring of Damper Plate & press into the Upper Cell Chamber firmly. (see Fig. 12)

4) Replace Safety Tape around lip of plate and the upper flow cell chamber.

b. Leakage Check - The system should be leak checked at 6" H<sub>2</sub>O by connecting a manometer to the outlet boss and evacuate the inlet to 6" H<sub>2</sub>O. No leakage should be observed.

c. Cleaning - To clean the exterior of the Bubble Generator use a mild detergent and warm water. NEVER USE ALCOHOL, ACETONE OR ANY OTHER HARSH CLEANERS TO CLEAN THE BUBBLE GENERATOR.

d. Transportation - When transporting the Glibrator, especially by air, it is important that one side of the seal tube which connects the inlet and outlet boss, be removed thereby allowing for equalizing internal pressure within the generator. Do Not transport unit with soap solution or storage tubing in place.

**CAUTION: Do Not Pressurize the Flow Cell! Excessive pressure may cause cell to rupture resulting in personal injury.**

**Section 6**  
**Printer Module Operation**  
**Part 1 C-800274**

**1. Introduction**

The Gilibrator Printer provides a hardcopy record of all calibration data, identical to data calculated and displayed on the LCD readout of the Gilibrator Control Unit (base).

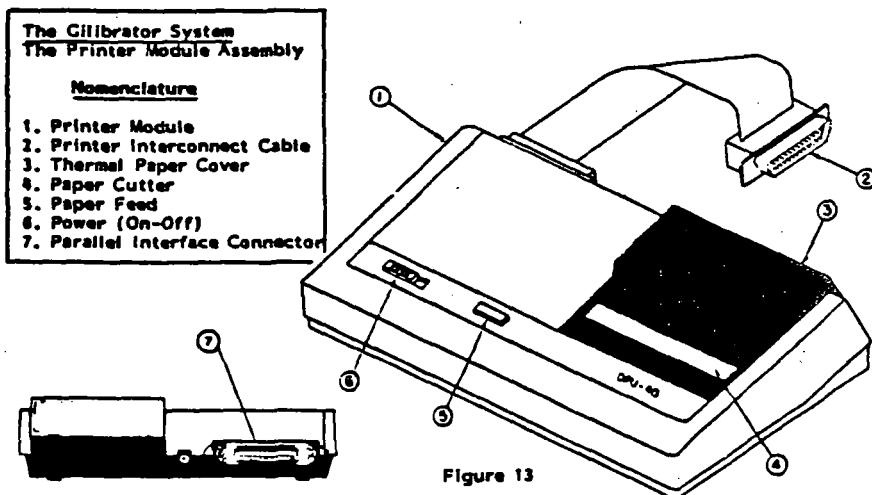
**Handling Precautions**

- a. Do not use where the temperature is extremely hot or cold.
- b. Do not leave in direct sunlight or where it is dusty.
- c. Do not operate near liquids or beverage.
- d. Do not operate without the heat sensitive roll paper loaded.
- e. Use only specified Gilian Replacement Roll Paper (A-800681).
- f. Do not attempt to disassemble the unit.

**NOTE:** The printer should only be used with the Gilian Interconnect Cable provided which supplies the power for the printer. Use of this printer with any other cable may cause permanent damage to the printer and to the equipment from which the cable is connected. The use of a non-shielded interface cable with the printer is prohibited.

**2. General Description (See fig. 13)**

The Printer is comprised of the following basic components: The Printer Module (1), Interconnect Cable (2) and the Thermal Roll Paper. A brief description is provided of their use and operation.



**a) Printer Module**

1. Power (6) - This switch activates operation of the printer from the Control Unit's power source. The printer will initially print a heading line upon activation.

2. Paper Feed (5) - This switch is used to feed the Thermal Paper continuously. Press it lightly. Note: Use the Paper Feed switch to feed out the paper. If paper is pulled out by hand, always feed it one line with the Paper Feed Switch before starting printing.

3. Paper Cutter (4) - This is used to tear of the paper. Tear off by pulling it in the arrow direction only.

b) Thermal Paper - A specially treated paper which is activated by the printer head.

c) Interconnect Cable (2) - The Interconnect cable provides electrical connection between the printer (1) and the Glibrator Control Unit (14). The printer operates from the same power source as the control unit.

**3. Theory of Operation**

The Printer Module is powered and interfaced to the Control Unit of the Glibrator by means of an Interconnect Cable. During a test series, the Control Unit transfers the sum of calculations of a given calibration bubble and provides the flow rate, the sample number and an average of the successive flow rates determined in that calibration series.

The buttons on the Control Unit are used in conjunction with the Printer module during calculation. Delete, Auto Average and Reset buttons are provided to subtract false readings and to initiate new calibration sequences.

Calculations are automatically provided by the Control Unit and transferred to the printer for a hardcopy readout. This is printed onto a thermal sensitive roll paper which advances a single line after printing out each successive reading. These hard copy calculations are retained for calibration records.

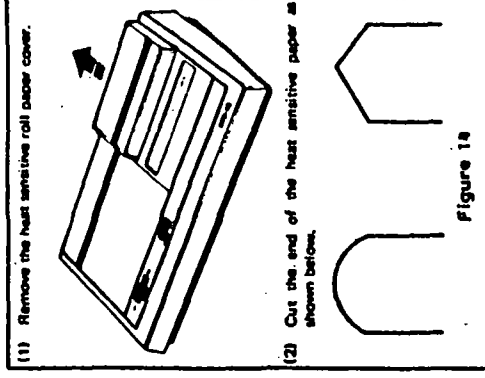
**4. Operation Procedures**

**a) Initial set-up**

**1. Connecting the Printer**

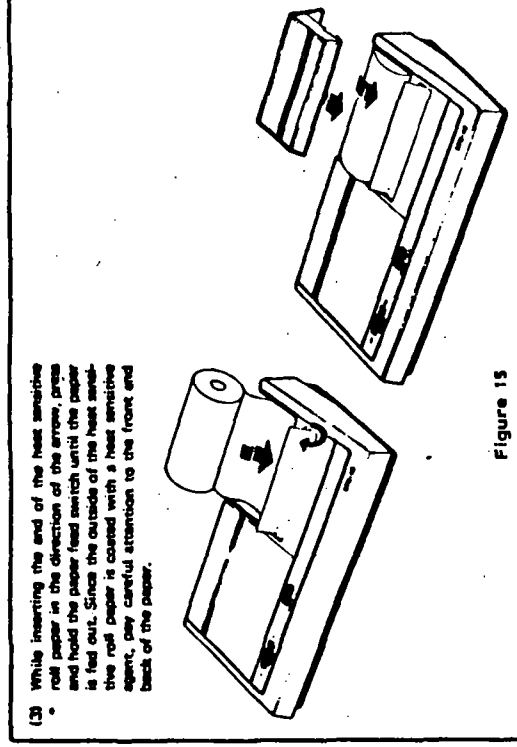
a) While the Glibrator Control Unit is in the OFF mode, connect the large end of the Interconnect Cable (2) to the Printer Modules Parallel Interface Connector and snap holding clips in place. Connect the smaller end to the Control Unit's Printer connect port. Power is supplied to the printer from the Control Unit's battery system.

**2. Turn ON the Control Unit and the Printer Module.**



3. Installing the Thermal Paper (See Fig. 14)

- a. Slide back and remove the Thermal Paper Cover (3) from the printer section. (see Fig. 14)
- b. Use the special Gillan heat sensitive roll paper (A-400881).
- c. Cut the end of the paper in a half circle or triangular shape.
- d. While inserting the end of the paper, press the Paper Feed Switch (5) until the paper is fed out. Replace protective paper cover. (see Fig. 15)



**b) Operation**

**1. Start Sequence**

a. Turn the Control Unit ON. The Printer Module will print out an identification heading for the current calibration test. The program version is indicated after the identification line for future reference. See sample below.

b. Initiate a bubble up the Flow Tube and observe the reading on the Control unit and also on the Printer Module. The Printer will print in sequence the flow, average and sample number after each successive reading.

**NOTE:** If you do not need a hard copy printout from the Printer Module, turn it OFF. This will preserve the battery life of the Gilibrator as the printer is powered by same.

**2. The Average, Reset and Delete buttons on the Control Unit are used in conjunction with the printer during calibration. They are as follows:**

a) Average - In order to display average and number of samples, depress and hold average button. Releasing the button will display the last reading. Repressing will display the number of samples accumulated for that averaging sequence. Releasing the button will once again display the last flow reading. Additional pressing and holding will repeat this sequence.

b. Reset - To reinitiate the sequence for additional pumps, hit the Reset Button. This will zero out sample and average registers within the Control Unit and will cause the printer to index one line and reprint headings. This denotes the start of a new sequence. The Reset Button may also be used if a malformed bubble is generated and has not been subtracted from the average by use of the Delete Function.

c. Delete - To delete obvious false readings, press the Delete Button and subtract the false reading from the average. This resets the average and sample number back to the previous reading.

**5. Storage & Maintenance**

**a) Storage (Daily Take Down)**

1. Turn the Power of the Printer Module OFF. All data stored in the printer cannot be reviewed once this is done.
2. Turn off the Power of the Control Unit.
3. Turn off the Power of the Sampler being calibrated.

**b) Storage (Long Term) - If the Printer Module is not to be used for long periods of time, the following steps should be taken to keep the unit in proper working order.**

1. Disconnect the interconnect cable from the Control Unit and from the Printer Module.
2. Store in original packaging or carrying case.

**c) Cleaning - Use a damp cloth with warm water. Never use ALCOHOL, ACETONE or any other harsh cleaners.**



**Section 7**  
**Specifications for the Gilibrator System**

**Flow Cell Assembly Ranges Available**

High Flow Cell	2 - 30 LPM
Standard Flow Cell	20 cc/min. - 6 LPM
Low Flow Cell	1 - 250 cc/min.

**Operational Features**

**Direct Flow Readings** - The easy to read LCD read-out on the Control Unit (base) instantly displays flow readings.

**Auto Averaging** - A switch on the Control Unit provides Auto-Averaging of the successive flow readings.

**Flow Delete Function** - A Flow Delete switch allows the user to delete erroneous flow readings from the Auto-Averaging function. For example, if a double bubble or other obvious malfunction is observed, that reading can be subtracted from the auto-average and will automatically reset the average to it's previous value.

**Programmable Update** - The micro-processor electronic design allows programmable updates to assure a long useful service life.

**Mechanical Features**

**Pulsation Damper** - The pulsation damper removes pulsation from the flow source for higher accuracy sampling as well as eliminating pulsations back into the flow source during bubble generation.

**Ring Bubble Generator** - The Ring Bubble Generator lifts an even soap film from the soap reservoir and provides consistent bubble generation.

**Bubble Breaker** - The Bubble Breaker design allows the soap film to be drawn away from the end of the flow tube before bursting. This improves flow measurement accuracy by minimizing film residue within the flow tube.

**Programmable Update** - The electronics design allows programmable updates to assure a long, useful service life.

**Accuracy** - Better than 0.5%

**Section 7 (cont'd)**  
**Gillibrator Printer Module Specifications**

<b>Printing System</b> Thermal dot matrix	<b>Character Font</b> 7x5 dot matrix
<b>Character Spacing</b> 2 dots	<b>Character Size</b> 2.4 (vertical) x 1.1 (horizontal) mm
<b>Character Set</b> 139 Alphabetic (upper and lower case), numeric, Kana, symbols	<b>Paper</b> Thermal Paper width 80 ± 1mm, roll diameter 40mm reorder Cilian Thermal Paper (3 rolls A-400681)
<b>Printing Direction</b> Left - right	<b>Printing Speed</b> 9.6 line/second
<b>Number of Columns</b> 40 columns/line	

**Section 8**  
**Parts List**

	<b>Part #</b>
High Flow Kit( (2-30 LPM)	D-800270
Standard Flow Kit (20cc - 6LPM)	D-800271
Low Flow Kit (1-250 cc/min)	D-800272
Deluxe	D-800275
High Flow Cell Assembly <u>only</u>	D-800265
Standard Flow Cell Assembly <u>only</u>	D-800266
Low Flow Cell <u>only</u>	D-800267
Safety Tape (10 ft.)	B-800331
Control Unit (base)	D-800268
Printer Module	C-800274
Printer paper (3 rolls)	A-400681
Battery Charger (120v)	B-400674
Flow Cell Soap	A-400450
Soap bottle dispenser	A-400667
Tubing	B-800269
Carrying Case	D-800273

Section 9  
Warranty

The Seller warrants to the Purchaser that any equipment manufactured by it and bearing its nameplate to be free from defects in material or workmanship, under proper and normal use and service as follows: If, at any time within 90 days from the date of sale, the Purchaser notifies the Seller that in his opinion the equipment is defective, and returns the equipment to the Seller's originating factory prepaid, and the Seller's inspection finds the equipment to be defective in material or workmanship, the Seller will promptly correct it by either, at its option, repairing any defective part or material or replacing it free of charge and returned shipped lowest cost transportation prepaid (If Purchaser requests premium transportation, Purchaser will be billed for difference in transportation costs). If inspection by the Seller does not disclose any defect in material or workmanship, the Seller's regular charges will apply. This warranty shall be effective only if installation and maintenance is in accordance with our instructions and written notice of a defect is given to the seller within such period. This warranty is exclusive and is in lieu of any other warranties, written, oral or implied; specifically, without limitation, there is no warranty of merchantability or fitness for any purpose. The liability of the Seller shall be limited to the repair or replacement of materials or parts as above set forth.

Limitation of Liability

The Seller shall not be liable for any claim for consequential or special loss or damage arising or alleged to have arisen from any delay in delivery or malfunction or failure of the equipment. The Seller's liability for any other loss or damage arising out of or connected with the manufacture, sale or use of the equipment sold, including damage due to negligence, shall not in any event exceed the price of the equipment supplied by us.

Service Policy

For a minimum fee of \$ 75., Gillian Instrument Corp. will overhaul, repair and/or replace minor components, and recalibrate one Gilibrator. Gillian reserves the right to proceed with additional repairs up to a maximum cost of \$100. per Gilibrator without notifying the customer. If major components must be replaced, Gillian will notify the customer before proceeding with repairs.

When the instrument(s) is returned, please include a purchase order marked "Repair Cost not to Exceed \$100. Without Customer Authorization". Also include company name, return shipping address, contact name and phone number, serial number(s) of calibrators, date of purchase and description of problem. Return to:

Gillian Instrument Corp.  
8 Dawes Highway  
Wayne, NJ 07470-6217  
Att: Gilibrator Repairs Dept.



ARGUS SUPPLY COMPANY  
15075 East Eleven Mile Road  
P.O. Box 880  
Roseville, Michigan 48062-0880  
(313) 774-8900

**OPERATING INSTRUCTIONS  
UNIVERSAL FLOW SAMPLE PUMP  
MODEL 224-PCXR7**

**UNIVERSAL FLOW SAMPLE PUMP**

**Model 224-PCXR7**

**OPERATING INSTRUCTIONS**

**SKC Inc.  
334 Valley View Road  
Eighty Four, PA 15330, USA**

**FORM 3764-REV706**

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## **A. DESCRIPTION**

### **INTRODUCTION**

The PCXR7 represents the culmination of two years of extensive research and development. It incorporates the first "on-board" computer, specially designed for ease of operation and the broadest flexibility ever offered in a portable sampler. Truly "state-of-the-art." In addition, the new high technology pneumatic system is the most energy efficient we've ever introduced. The result: unbeatable flow, back pressure, and run-time capabilities.

The PCXR7 is manufactured to the highest quality standards and will afford trouble-free operation when used in accordance with this manual. Please read carefully. It has been specifically designed for "on worker" and "fence line" applications in conjunction with sample collecting devices including filters, impingers, sampling tubes and color detector tubes.

State of the art Electronics -  
Powerful Pneumatics - Uncompromising  
Quality. The PCXR7 truly sets the new  
standard of excellence.

## **FEATURES**

- \* LCD Display
- \* Keyboard Control with Anti-tamper Cover
- \* Intermittent Sampling Capability  
Reduces Required Number of Samples
- \* 8 Hour TWA Test Now Possible
- \* Extended TWA Sampling up to 7 Days
- \* Automatic Timed Delayed Start
- \* Automatic Timed Shutdown
- \* Interrupt "Hold" Feature
- \* Total Time and Run Time Display
- \* High Accuracy Timer
- \* Broad Range - One to 5000 ml/min
- \* Handles Back Pressures to 40" Water Over Most Used Flow Ranges
- \* Constant Flow
- \* Pulsation-Free Flow
- \* Built-in Flow Indicator
- \* Multi-Low Flow Sampling Capability
- \* Fault Features
  - Lo Battery Shutdown
  - Pinched Hose Shutdown
  - Excess Back Pressure Shutdown
- \* Fault Shutdown with Time Retention
- \* Battery Charge Test
- \* Ultra Quiet Operation
- \* Heavy-Duty Impact-Resistant Case
- \* Replacement Parts in Preassembled Modules
- \* UL Listed Intrinsically Safe (Class I, Groups A, B, C, D; Class II, Groups E, F, G; and Class III)



**FEATURES (Continued)**

- \* Comprehensive One-Year Warranty
- \* Built-in Fluid/Particulate Trap
- \* External See-Through Filter Housing
- \* Stainless Steel Belt Clip
- \* External Exhaust Port
- \* Anti-Tamper Compensation Adjustments
- \* Easily Accessible Compensation Adjustments

## SPECIFICATIONS

### OPERATING

RANGE: 1-5000 ml/min (1-500 ml/min  
REQUIRES LOW FLOW CONTROL)

WEIGHT: 34 oz.

DIMENSIONS: 1-15/16" x 4-11/16" x  
5-1/8"; 44.7 cubic inches  
(732 cubic centimeters)

### COMPEN- SATION

RANGE: 750 ml/min - 5" to 40"  
Water Back Pressure  
1000 ml/min - 0" to 40"  
Water Back Pressure  
2000 ml/min - 0" to 40"  
Water Back Pressure  
2500 ml/min - 0" to 40"  
Water Back Pressure  
3000 ml/min - 0" to 35"  
Water Back Pressure  
4000 ml/min - 0" to 20"  
Water Back Pressure  
5000 ml/min - 0" to 15"  
Water Back Pressure

### FLOW

CONTROL: +5% Set Point Constant Flow

RUN TIME: 8 hours minimum at 4000  
ml/min and 20" water back  
pressure

### FLOW

INDICATOR: Built in Flow Indicator with  
250ml division; scale marked  
at 1, 2, 3, 4, & 5 LPM

### SPECIFICATIONS (Continued)

#### **BATTERY**

**ASSEMBLY:** Plug in battery pack,  
Rechargeable NiCad 2.0 AH,  
6.0 V. U/L Listed.  
Contains receptacle for  
charging out of pump.

#### **INTRIN- SICALLY SAFE:**

UL Listed for Class I,  
Groups A, B, C, D; Class II,  
Groups E, F, G; and Class  
III. Temp Code T3C.

#### **OPERATING TEMP:**

-20°C to +45°C  
(-4°F to +113°F)

#### **STORAGE TEMP:**

-40°C to +45°C  
(-40°F to +113°F)

#### **CHARGING TEMP:**

+5°C to +45°C  
(+41°F to +113°F)

#### **OPERATING HUMIDITY:**

0 to 95% Relative

#### **FLOW**

#### **FAULT:**

Fault shutdown with LCD  
Indicator and Time Display  
Retention if flow is  
restricted.

### SPECIFICATIONS (Continued)

#### BATTERY

TEST: LCD Indicator verifies battery condition prior to test.

#### TIME

DISPLAY: LCD Indicator displays time in minutes (Sampler run time, sampling period elapsed time or total elapsed time including delayed start time).

DELAY ON: Allows user to select minutes to delay start of test up to 9999 minutes (7 days).

#### TIMED

SHUTDOWN: Allows user to select minutes of operation before automatic shutdown

#### TIMING

ACCURACY:  $\pm .05\%$  ( $\pm 45$  seconds/day)

#### INTER- MITTENT

SAMPLING: Programmable to allow user to extend short term samples over an extended period of time to meet time weighted average requirements with a reduced number of samples. Elapsed time maximum is 9999 minutes (7 days).

## **SPECIFICATIONS (Continued)**

### **SAMPLING**

**PAUSE:** Allows user to temporarily halt sampling without loss of timing or programming data. Restart does not require resetting time.

### **MULTIPLE**

**SAMPLING:** Built in constant pressure regulator allows user to take up to four simultaneous samples of up to 750 ml/min each (total combined flow 1350 ml/min maximum) using optional low flow control.

### **ADDITIONAL**

#### **SPECIFICATIONS:**

- \* Built in fluid/particulate trap
- \* External see-through filter housing
- \* Anti-tamper control cover
- \* Anti-tamper compensation adjustments
- \* Accessory mounting provisions
- \* Stainless steel belt clip
- \* External exhaust port
- \* All non-plastic parts made of corrosion resistant materials

## DESCRIPTION (Continued)

### PNEUMATIC SYSTEM

The pneumatic system consists of five basic assemblies: 1) Pump/Valve, 2) Pulsation Dampener, 3) Pressure Regulator, 4) Flowmeter, and 5) Filter Assembly.

1) Pump/Valve Assembly: The Pump is of a dual silicone diaphragm design, driven by a high efficiency DC motor. The diaphragm pump is combined with special low pressure, positive acting valves. The pump mechanism is sealed to prevent dirt from entering. The DC motor operates from rechargeable NiCad Batteries, described in detail later.

2) Pulsation Dampener Assembly: Consists of a pair of silicone diaphragms within a housing. Two such assemblies are used to maintain pulsation-free flow and are located directly above the pump. In the intake stroke, the diaphragms are stretched inward by vacuum. In the exhaust stroke, the diaphragm elasticity forces the diaphragms apart, maintaining a continuous vacuum on the intake to the pump.

3) Pressure Regulator Assembly: This is used for low flow sampling from 1 to 750 ml/min. The purpose of the Regulator is to maintain 20 inches of water across a control restrictor. In high flow applications (750 ml/min and

#### DESCRIPTION (Continued)

up), the Regulator is not used. The Regulator consists of the sensing diaphragm with a pre-loaded spring that automatically opens or closes an air intake valve to recycle the air within the pump. When the Regulator is in the system, 20 inches of water pressure causes the Regulator to open and maintain that pressure. A manual valve is provided to connect the Regulator in or out of the system, as needed. It is located below the knurled cap screw (19) in Figure 1. The control of the Regulator is adjusted through opening screw under (21) in Figure 1. It is set at the factory for 20 inches of water and should not be tampered with except for service. A hex-head cap screw (Figure 1, #21) is used so that it may not be mistaken for the regulator valve (Figure 1, #19).

4) Flowmeter: This is a rotameter style flowmeter mounted vertically in the case. It is used to monitor the pump flow. Rotameters are not high precision flowmeters and should be backed up and set with a more precise film flowmeter. However, they are very repeatable and once the correct values have been established, they are very useful for setting the pump flow on a routine basis.

## DESCRIPTION (Continued)

5) Filter Assembly: Consists of a see-through housing and filter membrane held in place by an "O" ring. All air passes through the filter assembly. The transparent housing permits the operator to view the pump filter to determine when changing is necessary. (See Preventive Maintenance.)

## ELECTRICAL SYSTEM

The electrical control system consists of 1) the Battery Pack, 2) the Control Panel, 3) an Advanced Motor Control Circuit, and 4) an on-board computer.

1) Battery Pack: Consists of five NiCad cells in series to provide 6.0 volts at 2.0 AMP hour capacity to the Sampler. The pack is intrinsically safe and should be replaced only with U/L listed battery pack (SKC Catalog No. 224-30). **IMPORTANT!** See Battery Maintenance section for proper care of battery packs.

2) Control Panel: Consists of a) an LCD display for readout of battery condition, total elapsed time, pump run time, sampling period time, test status and set-up status, and b) a keyboard control pad for inputting sampling parameters and checking test status.



### DESCRIPTION (Continued)

3) Motor Control Circuitry: a) Constant Flow System - The Constant Flow System provides for constant air flow even though the back pressure of the collecting device may have increased, such as caused by dust accumulation on a filter. As the back pressure increases, the motor voltage is automatically corrected to maintain constant flow over the operating range.

b) Automatic Sampler Shutdown with Flow Stoppage or Low Voltage: If the collecting device used in conjunction with the pump should become plugged or the tubing pinched, the pump will automatically cut off. When this occurs, the pump will automatically go into "hold" mode. Total sampling period time will be displayed. Pump run time may be read by depressing "pump run time" key. Total elapsed time including delayed start may be read by pressing "Total Elapsed Time" key.

4) A specially designed on-board computer controls the timer with delayed start and intermittent sampling options: A timer is provided and will stop the pump after a preset number of minutes of run time, up to 9999 minutes. The user may also program a start test delay of up to 9999 minutes. In addition, the user may program a total sampling period in excess of the pump run time. Total sampling period may also be up to 9999

#### DESCRIPTION (Continued)

minutes. The on-board computer will automatically control the pump run time so that the sample is taken intermittently over the desired total sampling period, thus allowing TWA samples to be collected using fewer samples.

Leaving the power control switch in the "on" position allows the program to be run repeatedly by simply pressing the "set-up" key then the "start" key at the beginning of each test cycle. When storing the sampler for extended periods of time (in excess of one month) the power control switch should be moved from the "on" position to prevent over-discharging of the battery pack.

## **B. OPERATION**

### **1. HIGH FLOW APPLICATIONS (750-5000 ml/min)**

Refer to Figure 1, page 30

1) Charge unit for a minimum of 14 hours by connecting charger plug to Sampler charging jack (Figure 1, #24).

\*\*\*\*\*  
\* CAUTION! DO NOT CHARGE IN \*  
\* A HAZARDOUS ENVIRONMENT. \*  
\* USE ONLY SKC APPROVED CHARGER \*  
\* DESIGNATED FOR THIS MODEL. \*  
\*\*\*\*\*

2) Test the battery pack for full charge by turning the sampler on using "ON" switch (Figure 1, #8). Press the "Hold" key then the "Flow and Battery Check" key. Adjust the flow to 2 liters/minute using the flow adjustment control (Figure 1, #12 & 18). The LCD Display should indicate "battery OK" in the upper left-hand corner.

3) While in the battery test mode, connect calibrated flowmeter to filter housing intake (Figure 1, #14) using 1/4" tubing. Set Sampler to desired flow with flow adjustment control (Figure 1, #12). After completing the battery test and flow adjustment, press the "Flow and Battery Check" key to halt the sampler.

4) Connect the sampling media tubing to filter housing intake (Figure 1, #14). (For pressure applications, insert exhaust port fitting into exhaust port (Figure 1, #19) to make connection to exhaust port).

**CAUTION!** Impinger sampling requires in-line trap to prevent liquid fumes from accidentally being drawn into the Sampler. Single or dual impinger/trap holders may be mounted directly to the face of the Sampler using accessory mounting screws (Figure 1, #13).

\*\*\*\*\*  
\*      FAILURE TO USE THE TRAP VOIDS      \*  
\*                      THE WARRANTY.                      \*  
\*\*\*\*\*

5) While the pump is displaying "HOLD" on the LCD Display, the timing functions may be set. Press the "Set-up" key. "Delayed Start" will display on the LCD as well as a flashing digit. The value of the flashing digit will be incremented each time the "Digit Set" key is pressed. The "Digit Select" key is used to move the flashing digit. Using the "Digit Select" and "Digit Set" keys, enter the desired number of minutes delay before the sample period is to begin. Once the correct number of minutes is displayed, press the "Mode" key. "Sample Period" will now be displayed. Again, using the "Digit Select" and "Digit Set" keys as above, enter the desired total sampling period time in minutes. The total sampling

period is the total length of time over which the test is to be made and not the actual run time of the pump. If intermittent sampling is not desired, set the sample period equal to the pump run time. Press the "Mode" key when finished. "Pump Period" will now display. This is the actual number of minutes you wish the pump to run before automatically shutting down. Again, using the "Digit Select" and Digit Set" keys as above, enter the desired pump run time. If the pump run-time is less than the sampling period entered, the computer will automatically calculate and control the on/off cycling to complete the pump run-time in the time allotted. After completing, you may scan through your program by repeatedly pressing the "Mode" key. Each setting will display.

6) Start the test cycle by pressing the "Start/Hold" key at the beginning of the desired sampling period. The "Delayed Start" indicator will flash and the "Time" indicator will display the amount of time remaining until the sampling cycle starts if a time delay has been programmed. "Sample running" will display when the delay sequence has ended. The time display will automatically track the sampling period time elapsed.

7) Once the sampling period has begun, the user has the following options:

a) Normal shutdown - the Sampler will stop and the "sample over" indicator will light when the time set on the programmable timer has been reached.

b) Fault shutdown - if the flow becomes excessively restricted or the battery voltage drops below required level, the Sampler will shut down. The "Hold" indicator will light and the timing functions will freeze. Either the "Lo Battery" or the "Fault" indicator will light, depending on the cause of the shutdown. (In the case of flow fault or blockage, the test may be resumed if desired by correcting the flow blockage and pressing the "Start/Hold" key.

c) Pause - the Sampler will pause by pressing the "Start/Hold" key. All timing data will freeze. To resume sampling, again press the "Start/Hold" key.

d) Early shutdown - the Sampler may be shutdown at any time with no loss of stored time data by pressing the "Start/Hold" key.

e) The time indicator continuously displays the elapsed sampling period. The pump run time may be displayed at any time by pressing the "Pump Run Time" key. The total elapsed time (including the delayed start) may be displayed at any time by pressing the "Total Elapsed Time" key.

## 2. LOW FLOW APPLICATIONS (1-750 ml/min)

Refer to Figures 1 and 2, pages 30 - 32.

1) Charge unit for a minimum of 14 hours by connecting charger plug to Sampler charging jack (Figure 1, #24).

```
*****
*          CAUTION! DO NOT CHARGE IN          *
*          A HAZARDOUS ENVIRONMENT.            *
*          USE ONLY SKC APPROVED CHARGER        *
*          DESIGNATED FOR THIS MODEL.          *
*****
```

2) Test the battery pack for full charge by turning the sampler on using "ON" switch (Figure 1, #8). Press the "Hold" key then the "Flow and Battery Check" key. Adjust the flow to 2 liters/minute using the flow adjustment control (Figure 1, #12 & 18). The LCD Display should indicate "battery OK" in the upper left-hand corner.

3) Adjust the flow to 1.5 LPM (Figure 1, #12 & #18). NOTE: the flow is not critical but must exceed the combined sampling flows by at least 150

ml/min. After completing the battery test and flow adjustment, press the "Flow and Battery Check" key to halt the sampler.

4) Remove the protective cap covering the regulator shutoff cap screw (Figure 1, #19). Using the large screwdriver supplied, open the regulator shutoff valve by turning the adjustment screw 3 turns counter-clockwise. Replace the protective cap.

5) Connect an adjustable flow holder (Figure 2) using tubing supplied to the filter housing intake (Figure 1, #14).

6) Break the tips off the sample tube(s) to be used. IMPORTANT! 2.5mm opening minimum in each end of tube required. Place tube(s) in the manifold's rubber connector with the arrow pointing toward the manifold.

CAUTION! Long duration color tubes require a special tube cover (see Optional Accessories) which allows the addition of an inline trap tube. Long duration color tubes outgas caustic fumes which must be trapped to prevent damage to low flow manifold and Sampler.

\*\*\*\*\*  
\* FAILURE TO USE THE TRAP VOIDS \*  
\* THE WARRANTY. \*  
\*\*\*\*\*



7) Connect calibrated flowmeter (see Optional Accessories) to the exposed end of the sample tube(s). Loosen the anti-tamper cover on the manifold to expose the manifold's flow adjustment screw(s). Turn on the Sampler and turn the manifold's flow adjustment screw(s) until the desired flow rate is obtained. Turn off the Sampler and place the protective covers over the sample tubes.

8) While the pump is displaying "HOLD" on the LCD Display, the timing functions may be set. Press the "Set-up" key. "Delayed Start" will display on the LCD as well as a flashing digit. The value of the flashing digit will be incremented each time the "Digit Set" key is pressed. The "Digit Select" key is used to move the flashing digit. Using the "Digit Select" and "Digit Set" keys, enter the desired number of minutes delay before the sample period is to begin. Once the correct number of minutes is displayed, press the "Mode" key. "Sample Period" will now be displayed. Again, using the "Digit Select" and "Digit Set" keys as above, enter the desired total sampling period time in minutes. The total sampling period is the total length of time over which the test is to be made and not the actual run time of the pump. If intermittent sampling is not desired, set the sample period equal to the pump run time. Press the "Mode" key when finished. "Pump Period" will now display. This is the actual number of

minutes you wish the pump to run before automatically shutting down. Again, using the "Digit Select" and Digit Set" keys as above, enter the desired pump run time. If the pump run-time is less than the sampling period entered, the computer will automatically calculate and control the on/off cycling to complete the pump run-time in the time allotted. After completing, you may scan through your program by repeatedly pressing the "Mode" key. Each setting will display.

9) Start the test cycle by pressing the "Start/Hold" key at the beginning of the desired sampling period. The "Delayed Start" indicator will flash and the "Time" indicator will display the amount of time remaining until the sampling cycle starts if a time delay has been programmed. "Sample running" will display when the delay sequence has ended. The time display will automatically track the sampling period time elapsed.

10) Once the sampling period has begun, the user has the following options:

a) Normal shutdown - the Sampler will stop and the "sample over" indicator will light when the time set on the programmable timer has been reached.

b) Pause - the Sampler will pause by pressing the "Start/Hold" key. All timing data will freeze. To resume sampling, again press the "Start/Hold" key.

c) Early shutdown - the Sampler may be shutdown at any time with no loss of stored time data by pressing the "Start/Hold" key.

d) The time indicator continuously displays the elapsed sampling period. The pump run time may be displayed at any time by pressing the "Pump Run Time" key. The total elapsed time (including the delayed start) may be displayed at any time by pressing the "Total Elapsed Time" key.

### **C. PREVENTIVE MAINTENANCE**

This section provides the user periodic maintenance tips on battery charging, air inlet filter checking and replacement and leak detection.

#### **BATTERY PACK**

Refer to Figure 1, page 30.

**Removal** - Remove the two screws (Figure 1, #22) which secure the battery pack (Figure 1, #23) to the case front and loosen the four case screws above and below the belt clip. Carefully slide the battery pack out to the right from under the belt clip (Figure 1, #25) being careful not to cock it at an angle. Edge rails should guide pack out.

**Replacement** - Stand the pump vertically on a flat surface. Slip the front edge of the battery pack (Figure 1, #23) under the belt clip (Figure 1, #25) and rotate the battery pack so the rails engage the slots on the case front. Push the battery pack to the left until it is properly located and reinstall screws (Figure 1, #22) and tighten the case screws.

**Battery "Memory Effect"** - The NiCad battery pack supplied with the SKC Sampler should be completely discharged from time to time to minimize the potential for "memory effect" which occurs frequently with rechargeable batteries. "Memory effect" is a

characteristic of all NiCad cells and prevents the batteries from fully recharging, even though a full charge is indicated. This would prevent the pump from running a full 8 hour sample period in some instances. Approximately every 10 recharges:

1. Turn on pump using the "ON" switch (Figure 1, #8).

2. Set flow rate to 3 liters/minute with no load on intake port.

3. Allow pump to run until fault circuit cuts pump off. "Lo Battery" indicator should light.

4. Turn pump off and charge battery for a full 14 - 16 hours.

5. After charging, check battery by pressing the "Battery Check" key with the flow set to 1 - 2 liters/minute, to assure battery has received charge. "Battery OK" indicator will light indicating full charge.

NOTE: After several hundred rechargings, NiCads lose performance characteristics and should be discarded if pack fails to hold charge.

Spare Battery Packs/Infrequent Use - NiCad batteries may not provide full current capacity if left unused over extended periods of time. Rotate the use of any spare pack to avoid idle periods in excess of one month. Fully charge packs before or after use or storage.

\*\*\*\*\*  
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\*\*\*\*\*

#### PUMP INLET FILTER

The SKC Sampler is fitted with a filter/trap inside the clear plastic intake port housing. This prevents particulates and liquids from being drawn into the pump mechanism. Occasional attention should be taken to assure that the filter is not becoming clogged and creating an excessive load on the pump. If it is determined that maintenance is necessary: (Refer to Figure 1)

1. Blow all dust and debris from around the filter housing.
2. Remove the four screws (Figure 1, #15) and the front filter housing.
3. Remove and discard the filter membrane (Figure 1, #17) and "O" ring (Figure 1, #16).
4. Clean the removed filter housing.
5. Insert a new filter membrane and "O" ring per Figure 1. (Filter Replacement Kit, SKC Catalog No. 224-09)
6. Insert the four screws (Figure 1, #15) and cross tighten secured to rear housing within is the case.

## SETTING THE FLOW COMPENSATION

Refer to Figure 1, page 30.

NOTE: Compensation is factory preset to cover the most common range of NIOSH/OSHA tests. It is necessary to reset the compensation only if: 1) non-factory repairs have been made, or 2) greater precision is desired at a particular flow rate.

1) To set the flow compensation, remove the anti-tamper cover screws on the side of the sampler (Figure 1, A and B).

2) Set the sampler flow rate to 1000 ml/minute using the flow adjustment control (Figure 1, #8). Apply 25" water back pressure to the inlet of the sampler and note the change in flow on the flowmeter (Figure 1, #18) or external flow calibrator. If the flow increases, turn the compensation adjustment pot "A" (located through the hole vacated by the anti-tamper screw) clockwise until a flow rate of 1000 ml/min obtained. If the flow decreases, turn the compensation adjustment pot "A" slightly counterclockwise until a flow rate of 1000 ml/min is obtained.

3) Set the sampler flow rate to 2500 ml/minute using the flow adjustment control (Figure 1, #8). Apply 25" water back pressure to the inlet of the sampler and note the change in flow as

above. If the flow increases, turn the compensation adjustment pot "B" (located through the hole vacated by the anti-tamper screw) counterclockwise slightly, which will further increase the flow. If the flow decreases, turn the compensation pot "B" clockwise slightly to further decrease the flow. Remove the back pressure and repeat step 3 until the change of flow is within 5%.

4) At this point, repeat steps 2 and 3 since there is interaction between the compensation pots. Replace the anti-tamper cover screws. NOTE: if the most precision is desired at a particular flow setting, the above procedure may be used at that setting. For this purpose, it is helpful to note that compensation pot "A" has the most effect at lower flow rates and compensation pot "B" has the most effect at higher flow rates.

#### SETTING PRESSURE REGULATOR (Low flow mode)

Refer to Figures 1 and 2, pages 30 - 32.

Turn the "ON" switch to "ON". Adjust the flow adjustment control (Figure 1, #12) to 1.5 liters/min. Remove the protective cap screw (Figure 1, #19). With a screwdriver, open the Pressure Regulator shutoff valve located under cap screw (Figure 1, #19) by turning it counterclockwise three turns.



This now places the Pressure Regulator into the pump system. CAUTION: Pressure Regulator shutoff valve must be open else water will be pulled into the pump and damage will occur. A trap is desirable to prevent this from occurring accidentally. The trap must be positioned in line between the pump and manometer. Connect the pump intake port directly to the trap and a water manometer that is at least 36" in length. Remove the protective cap screw (Figure 1, #21) and adjust the pump suction pressure to 20" water by turning Pressure Regulator Adjust Screw located under cap (Figure 1, #21) clockwise to increase pressure and counter-clockwise to decrease pressure. The pump is now set for low flow operation between 1 and 750 cc/min. The pump may be set exactly for any specific flow by using the Low Flow Control (SKC Catalog No. 224-26-01, -02, -03, -04). (See Optional Accessories)

To return the pump to high flow operation, turn the regulator shutoff screw clockwise until it stops and Replace the protective cap screw.

NOTE: SKC U/L Battery Packs (SKC Catalog No. 224-30) contain a protective device to eliminate potential short circuiting while the pump is in use. If the charger's red charging light is on prior to attachment to the battery pack, the charger is defective and must not be used. If the red charging light on the charger does not light while charging,

the charging circuit is open either in the pack or charger unit, or the wall outlet is inoperative. Process of elimination should indicate which unit is defective. If you are unable to determine which is defective, please contact SKC's Customer Service Department (412-941-9701) for further assistance.

\*\*\*\*\*  
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\* DESIGNATED FOR THIS MODEL. \*  
\*\*\*\*\*

#### **D. OPTIONAL ACCESSORIES**

##### **Adjustable Flow Holders:**

224-26-01	Single Holder
224-26-02	Dual Holder
224-26-03	Tri Holder
224-26-04	Quad Holder

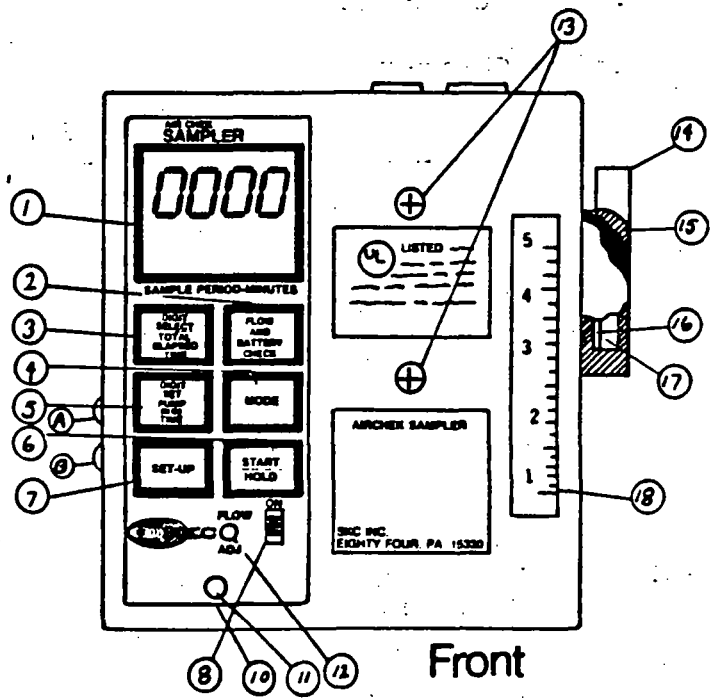
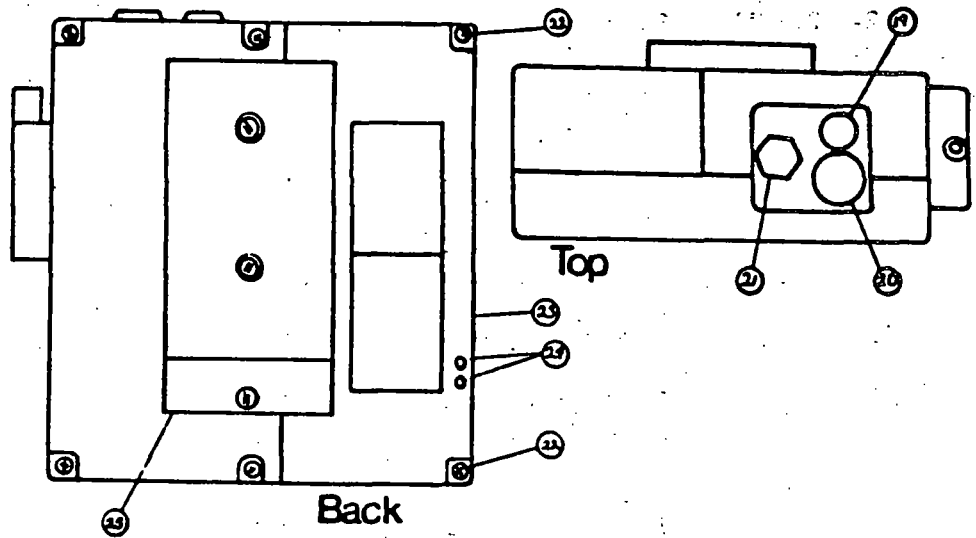
##### **Protective Covers:**

224-28A	NIOSH Charcoal, standard tubes 6mm OD x 70mm length
224-28B	Standard tubes 8mm OD x 110mm length
224-28C	Standard tubes 10mm OD x 150mm length
224-28D	Standard tubes 10mm OD x 220mm length and shorter tubes
224-28T	Color Detector Tube Holder - 15mm OD x 115mm primary tubes, 15mm OD x 55mm back-up tubes

##### **Battery Chargers:**

224-31	Single Battery Charger 115V
224-31B	Single Battery Charger 230V
224-31SCR	Deluxe Battery Charger - Dual Rate, Auto Switching, 115V
224-31SCR	Deluxe Battery Charger - Dual Rate, Auto Switching, 230V
224-32	5 Pump Multiple Battery Charger 115V
224-32B	5 Pump Multiple Battery Charger 230V
224-32SCR	Deluxe 5 Station Battery Charger, Auto Switching, 115V
224-32SCRB	Deluxe 5 Station Battery Charger, Auto Switching, 230V
224-11	Sampler Tool Kit

**Figure 1 - Model 224-PCXR7**

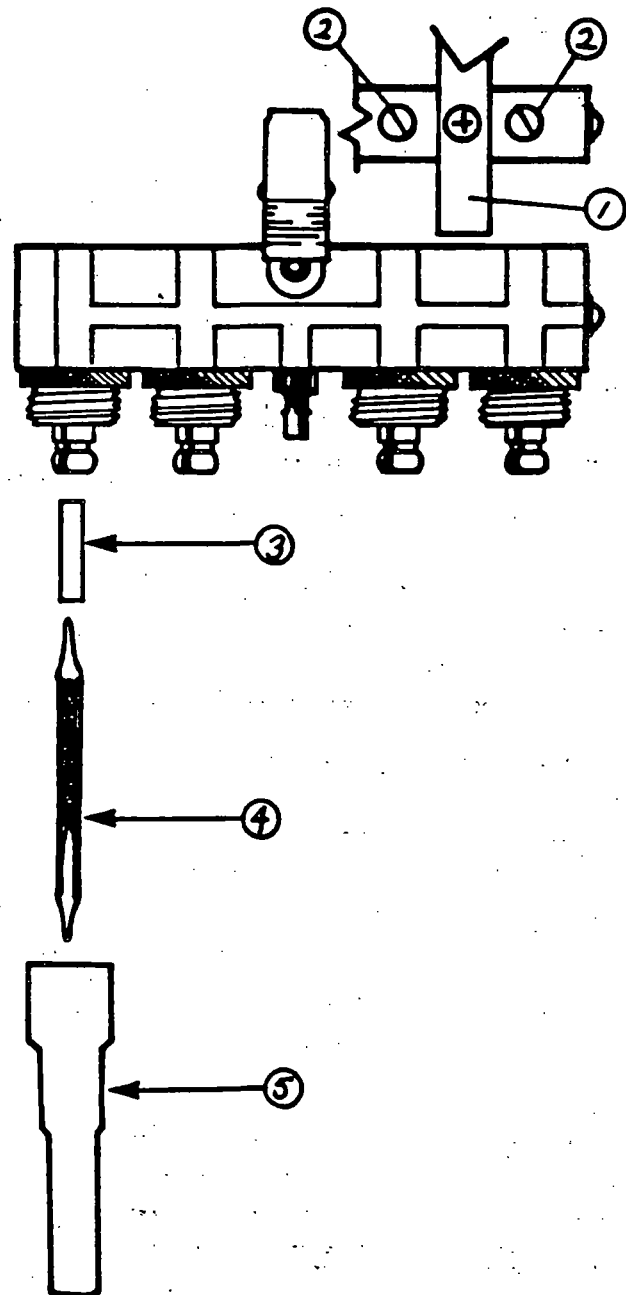


## **E. DIAGRAMS/GLOSSARY**

**Figure 1 - Model 224-PCXR?**

<b><u>NO.</u></b>	<b><u>DESCRIPTION</u></b>	<b><u>FUNCTION</u></b>
1	LCD Display	Indicators for all sampler functions
2	Flow and Battery Check Key	Allows setting flow rate and testing battery condition
3	Digit Select/Total Elapsed Time Key	Allows selecting which time digit is being set when in set-up mode or viewing total elapsed time during the actual sampling cycle
4	Mode Key	During set-up allows changing between delayed start, pump run time and total elapsed time
5	Digit Set/Pump Run Time Key	Allows setting the flashing digit to the desired value or viewing the actual pump run time during the actual sampling cycle
6	Start/Hold Key	Used when ready to begin the sampling cycle, pause the sampling cycle and restart the cycle after pause
7	Set-up Key	Allows setting the delayed start time, pump run time and total elapsed time desired
8	"ON/STORE" Switch	Allows the pump to be shut down completely for long periods of storage (over 10 days)
10	Anti-tamper cover	Protects controls from incidental contact or tampering
11	Cover Screw	Fastens anti-tamper cover
12	Flow Adjustment Control	Adjusts flow from 750-5000 ml/min
13	Accessory Mounting Screws (2)	Secure accessories such as impinger and trap holders
14	Filter Housing (intake)	Air intake port and trap
15	Screws (4)	Secure filter housing
16	Filter O-ring	Positive leak seal for filter in housing
17	Filter (10 micron nylon)	Filtrates particulates before entering pump
18	Built-in Flowmeter	Monitors for flow changes
19	Regulator Shut-off Cap Screw	Accesses regulator shut-off valve
20	Discharge Air Cap Screw	Accesses Exhaust Port
21	Regulator Adjustment Cap Screw	Accesses regulator pressure adjust
22	Battery Pack Screws (2)	Secures pack to pump
23	Battery Pack Assembly	Provides power to pump
24	Charging Jack	Connector for battery charger
25	Belt Clip	Secures Pump to worker
A	Compensation Pot A Anti-tamper Cover	Protects compensation pot A from accidental adjustment
B	Compensation Pot B Anti-tamper Cover	Protects compensation pot B from accidental adjustment

## Adjustable Flow Holder



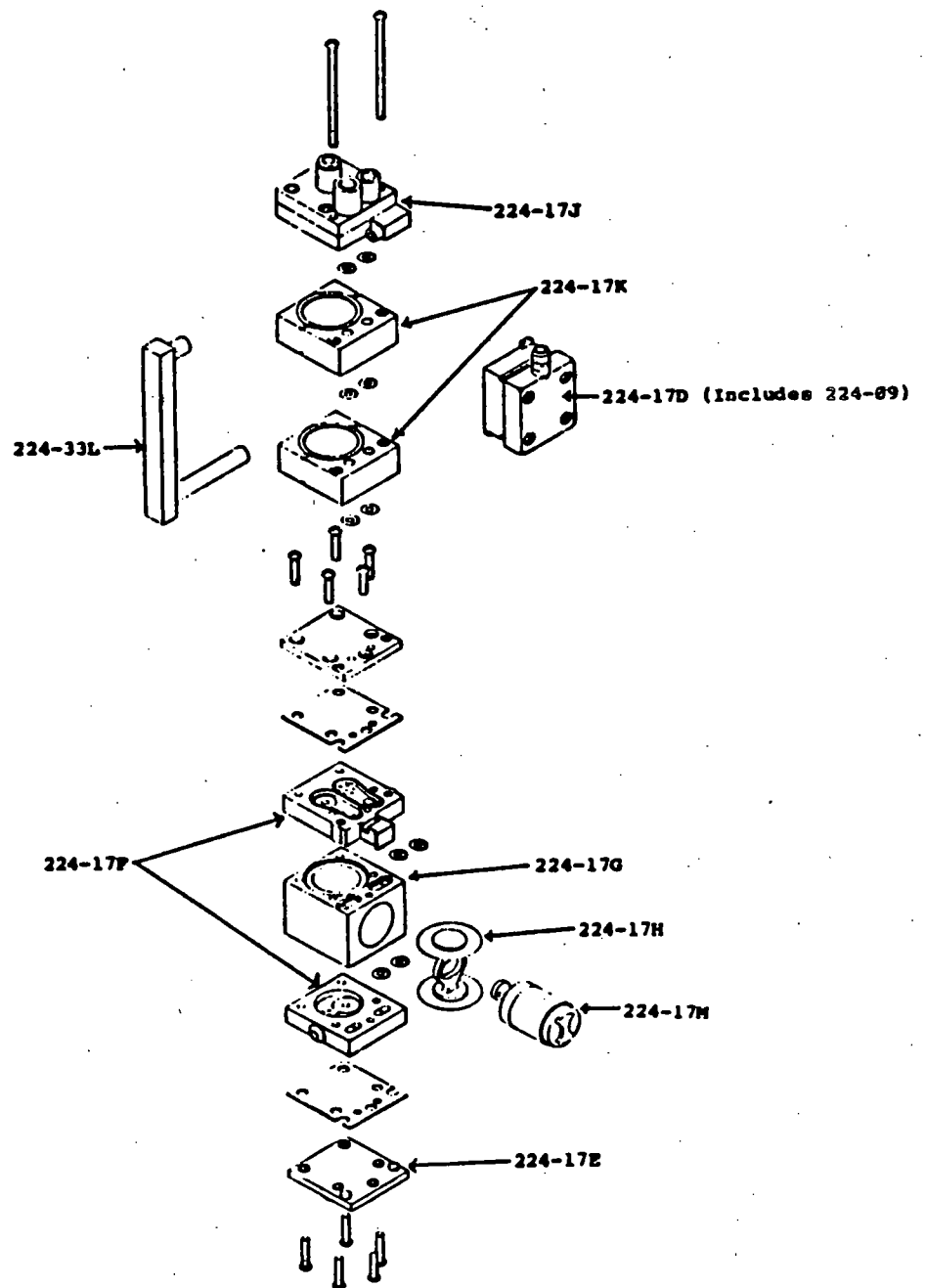
**Figure 2 - Adjustable Flow Holder**

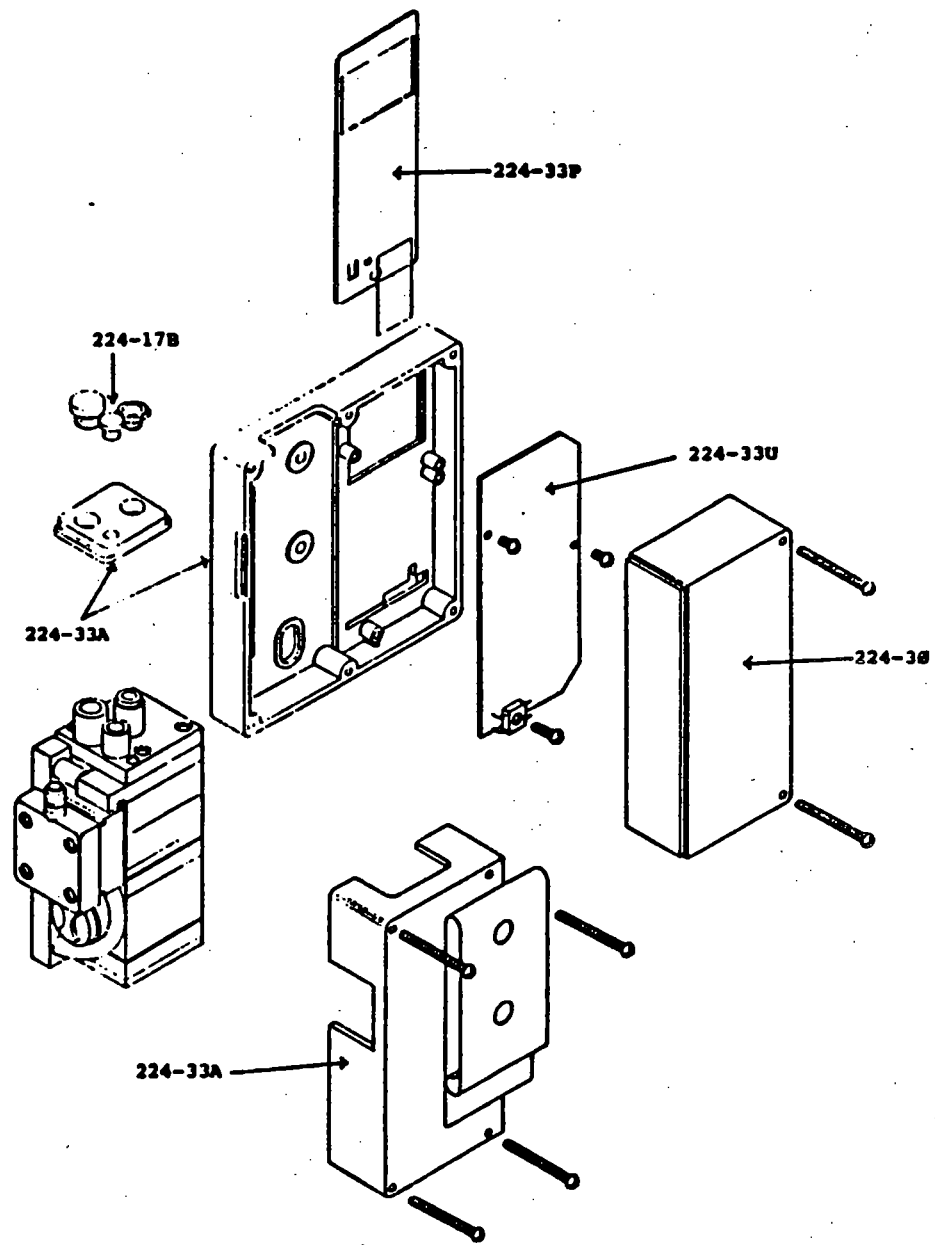
<b><u>NO.</u></b>	<b><u>DESCRIPTION</u></b>
<b>1</b>	<b>Anti-tamper Cover</b>
<b>2</b>	<b>Manifold Flow Adjustment</b>
<b>3</b>	<b>Rubber Connector</b>
<b>4</b>	<b>Sorbent Sample Tube</b>
<b>5</b>	<b>Protective Cover</b>

**Figure 3 - Replacement Parts**

224-09	Replacement Filter Kit
224-17B	Cap Screws (set of 3)
224-17C	Exhaust Port Fitting
224-17D	Filter Housing Assembly
224-17E	Pressure Switch Assembly
224-17F	Valve Plate Assembly
224-17G	Pump Body
224-17H	Diaphragm/Yoke Assembly
224-17J	Regulator Assembly
224-17K	Pulsation Dampener Assembly (set of 2)
224-17M	Motor/Eccentric Assembly
224-30	Battery Pack Assembly
224-33A	Case Parts (Excluding Battery Case)
224-33L	Flowmeter Assembly
224-33P	Keyboard Assembly
224-33U	Control Board









**UNDERWRITERS LABORATORIES INC.**

333 PFINGSTEN ROAD • NORTHBROOK, ILLINOIS 60062

*an independent, not-for-profit organization testing for public safety*

**CERTIFICATE No. Ex.110287-62011**  
**11 February 1987**

**Issued to:**

**SKC Inc..  
R. D. 1 No. 395 Valley View Rd.  
Eighty-Four, PA 15330  
U.S.A.**

**This is to certify that: Intrinsically safe portable air pumps, Models 224-PCXR3, 224-PCXR7 and 224-43XR, when used with the self-contained 6.0v battery pack, SKC Model 224-30 has been investigated by Underwriters Laboratories Inc. in accordance with the standard indicated in this certificate.**

**UL Standard for Safety:**

**ANSI/UL/NFPA 4913-1979 (UL913-1979) Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations.**

**The Air Sampling Pumps comply with the requirements as defined by the standard indicated in this document for intrinsically safe equipment for use in Class I, Groups A,B,C, and D and Class II, Groups E, F and G and Class III hazardous locations.**

**To establish that a product is under the Certification program it is necessary to determine that the product has been manufactured under UL's Follow-Up Service. The Listing Mark of Underwriters Laboratories Inc. on the product is the only method provided by UL to identify a product manufactured under its Follow-Up Service. The Listing Mark includes the symbol of Underwriters Laboratories Inc. "®" together with the word "Listed" and the control number 124U.**

**Code: Intrinsically safe: Class I, Group A, B, C and D and Class II, Groups E, F and G and Class III, Temperature Code T3C.**

**Tamb- 40C**

**Albert A. Bartkus  
Associate Managing Engineer  
Hazardous Locations  
Casualty and Chemical  
Hazards Department**

**Investigation and Test  
Report Reference:  
E62011, 20 January 1987**

**Look For The ® Listing or Classification Mark On The Product**

UNDERWRITERS' LABORATORIES INC.

LISTING OR CLASSIFICATION  
AND  
FOLLOW-UP SERVICE

The promulgation of UL Listing or Classification is contingent upon the establishment of UL's Follow-Up Service, designed to serve as a check on the means which the manufacturer exercises to determine compliance of the product with UL's requirements. Under the Follow-Up Service, the manufacturer attaches labels, markers or other authorized evidences of Listing ("Listing Marks") or Classification ("Classification Markings") to such of his products as are found by him to be in compliance with UL's requirements. Representatives of UL make periodic examinations or tests of the products at the factory and may from time-to-time, select samples from the factory, the open market, or elsewhere, to be sent to a UL testing station for examination and or test to determine compliance with UL's requirements. Should examination or test by UL's representative disclose features not in compliance with the requirements, the manufacturer is required either to correct such items or to remove the Listing Mark or Classification Marking from the product.

The appearance of catalog or model numbers or other specific product designation on the Certificate signifies that samples of such products have been submitted to UL and found to comply with the applicable requirements and that the manufacturer has been authorized to use the appropriate Listing Mark or Classification Marking on production that continues to comply with the requirements. The manufacturer is not obligated to label all of his production, and products which do not bear the Listing Mark or Classification Marking are not required by UL to comply with UL's requirements. Accordingly, the appearance of a specific product designation on the Certificate does not in itself assure that products so specified or identified will be or have been produced under UL's Follow-Up Service. The manufacturers' products are not counterchecked under UL's Follow-Up program unless they bear the UL Listing Mark or Classification Marking. Only these products bearing the appropriate Listing Mark or Classification Marking and the company's name, trade name, trade-mark, or other recognized identification should be considered as covered by UL's Listing or Classification and Follow-Up Service.